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THE ARCHITECTURE OF ENABLING TECHNOLOGY IN THE CRITICAL CARE SETTING: THE ROLE OF ARCHITECTURE IN ADDRESSING THE HEALTH CARE - TECHNOLOGY PARADOX

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ABSTRACT

Health care architecture, particularly tertiary care settings, which have the sickest people, and most advanced medical care, should accommodate and employ technology in ways that are both therapeutic and enabling. Although technology in the tertiary care setting is generally considered beneficial, it can sometimes have negative impacts, cause stress and result in poor health outcomes. Norman Cousins said in his book *Anatomy of an Illness*, “Many doctors are increasingly aware of the circular paradox [of the intensive care unit]. It provides better electronic aids than ever before for dealing with emergencies that are often intensified because they communicate a sense of imminent disaster to the patient.” These negative side effects are typically the result of disabling technology, which above all restricts a patients’ ability to have and to sense comfort and control. This health care - technology paradox is often activated through medical equipment, medical practices and medical settings. When medical practices and medical equipment are disabling and do not sufficiently enable comfort and control, then the medical setting can play a role in helping to temper the paradox and hence total impact technologies have on the patient.

In order to temper the health care – technology paradox, the architecture of health care environments should accommodate and employ technology in ways that are both therapeutic and enabling, are calming and reassuring, and allow for comfort and control. To provide for increased comfort and control, architecture should address the paradox by being orienting and comprehensible, engaging and stimulating, and allowing flexibility and reconfiguration. At the same time, it must be therapeutic while generally effectively accommodating medical equipment and practices. Specifically, comfort and control can be provided by implementing technology to enable an environment that is more comprehensible and better orienting. It can also be provided by implementing technology to enable a variety of spatial configurations that accommodate diverse activities as well as provide opportunities for mobility and stimulation by engaging the environment. Comfort and control can also be provided by implementing technology to enable personal optimization of the environment.

Since the health care – technology paradox is most prevalent in the tertiary, or critical care settings, this thesis proposes a Heart Hospital for the Laguna Honda section of San Francisco, California. This facility will integrate enabling technology that brings together sophisticated medical equipment and advanced medical practices with the most complex medical settings to help provide comfort and control to the one of the most compromised patient populations. The design centers on the concept of a “hospital within a hospital” that is enabled by decentralization as a result of the wide-spread usage of information technology throughout the hospital. The smaller and thinner floor plates that are a characteristic of this proposal allows simplified building massing and organization which provides for better orientation and comprehension of space. Over time, hospitals tend to be convoluted by chaotic addition and changing medical technology, but by providing a hospital framework that is regular and pre-dictable, this change can be controlled to maintain the clarity of space and wayfind-ing. Lastly, the proposed tertiary care spaces are designed to allow for flexibility and reconfiguration of space so that patients can adapt their setting to suit their personal and emotional needs.

DEDICATION

This thesis is dedicated to my parents, Ed and Marie, who have instilled in me a rigorous work ethic and a never-ending will to succeed. I cannot thank you enough for the amount of support you have given me through the years. Thank you for unconditional love, guidance and belief in me.

This thesis is especially dedicated to my loving and patient wife Cheryl who has lived and endured with me through these past five years. We have now done this twice together and although it was not easy either time, our mutual mental and emotional support for each other most certainly helped along the way. I know I was stubborn and doubtful at first, but you urged me to remember where I came from, to persevere, succeed, achieve the goals that I set to accomplish and finish what I began. Thank you very much. Lo Ti Amo!

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To my studio colleagues: Cheryl Nicole Bacsik Nitch, Shae Hensley, Maurie Duderstadt and Anthony Carmola. Five years goes by very fast!

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INTRODUCTION

Figure 1. Technology can sometimes result in negative impacts.

Figure 2. Technology can communicate imminent danger.

The architecture of critical care environments should accommodate and employ technology in ways that are both therapeutic and enabling. In relatively recent history, health care has been highly influenced by technology, and statistics show that improvements in technology generally correlate to overall improvements in health. Although technologies are generally considered useful and practical and enable life to be easier and more efficient, they sometimes can have negative impacts, cause poor results and be disabling to patients. This situation where technology causes conflicting effects compared to what was intended presents a paradox. This paradox should be addressed and, if possible, resolved before the technology can be considered ultimately beneficial. Norman Cousins describes the paradox in his book *Anatomy of an Illness*, "Many doctors are increasingly aware of the circular paradox [of the intensive care unit] (Cousins, pg. 133). It provides better electronic aids than ever before for dealing with emergencies that are often intensified because they communicate a sense of imminent disaster to the patient." What Cousins alludes to is that technology can be stressful and disabling, and create adverse health effects by inhibiting a persons'

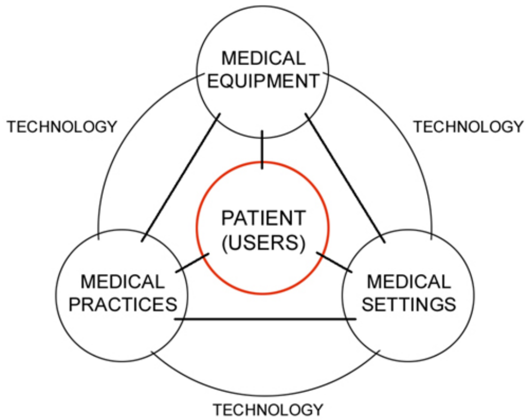

Figure 3. Health care - Technology Paradox Paradigm.

Figure 4. Tertiary Care Center: Trauma Room.

ability to have and to sense comfort and control.

When technology, operating through medical equipment, medical practices or medical settings, negatively influences the patient, the paradox activates and the health care experience is compromised. The Health-Care Technology Paradox Paradigm in Figure 3 shows diagrammatically that technology, which is the common influence amongst the three factors, encompasses medical equipment, practices and settings, which are implemented to provide a positive impact on the long-term life of the patient. This thesis will focus on medical settings, which are highly functional places that contain and interface with medical equipment and have significant requirements in order to support medical practices. The most significant settings where the paradox occurs are tertiary medical centers, such as the I.C.U. and trauma room because they contain the most sophisticated medical equipment, demand and deliver the most advanced medical care to the sickest patients who have longer hospital stays and are often still aware of their surroundings. When medical practices and medical equip-

Figure 5. A confining, inflexible and unreassuring environment.

ment are not sensitive to the concerns of comfort and control, the medical setting can therefore help temper the paradox and the total impact technologies have on the patient.

Comfort and control should be provided through enabling technologies to create a less stressful, and therefore, a more calming, and reassuring environment that is conducive to healing. The types of stress caused by technology include disorientation, inflexibility and confinement. Intensive medical settings should compensate for the negative impacts of technologically evolving medical practices and equipment by addressing patients' experiential needs through the appropriate architectural accommodation of enabling technologies. To provide for increased comfort and control, architecture can address the paradox by generally being reassuring and comprehensible, engaging and stimulating, and providing flexibility to allow for change. At the same time, it must do this while generally providing a therapeutic environment and effectively accommodating enabling medical equipment and practices. Specifically, comfort and control can be provided by ever changing personal optimization of the environment, providing a variety of spatial configurations that accommodate diverse activities, and providing opportunities for mobility, stimulation and engaging the environment. Technology should be employed when and where it can enable an environment that is more comprehensible and better orienting. When given a choice, patients and health care consumers voluntarily seek those medical settings with the best medical practices and equipment because they are reassuring and generally result in the best health care outcomes. If these advanced medical technologies and practices are readily available, then people will seek those medical settings, including it's technology, that are most therapeutic and enabling.

Technology is often what drives the design of the floor plate and has the propensity to result in chaotic change over time. Technologically intensive tertiary care settings should be designed with an orderly, regular and predictable footprint and framework that has simple, clear and direct paths yet still retains flexibility to accommodate ever

Figure 6. Information Technology.

changing medical equipment and medical practices. Decentralization of the hospital, due to the widespread use of information technology, will enable a smaller hospital and thus a better ability to provide simplified buildings. Tertiary care settings in particular should be designed to utilize the advantages associated with information technology and the decentralized hospital to enable smaller and thinner building floor plates instead of widespread, massive buildings. By reducing the size and amount of clinical services, relying on remote communication methods, and spreading the remaining services around the building, the organization and structure of the hospital can change dramatically. The result is a hospital within a hospital concept that will allow smaller and more compact building footprints. Lastly, tertiary care settings should be designed to utilize simple mechanisms that optimize control and improve physical aspects of the environment where patients spend the most time. Tertiary care settings are the most applicable because they are settings where patients typically require longer hospital stays.

Since the health care – technology paradox is most prevalent in critical care settings, this thesis proposes a Heart Hospital for the Laguna Honda section of San Francisco, California. This facility will be an integration of enabling technology that brings together sophisticated medical equipment and advanced medical practices with the most complex medical settings to help provide comfort and control to the one of the most incapacitated patient populations. Heart Hospitals are the most significant settings for exploring the architecture of enabling and therapeutic technology, and hence the paradox, because they demand and deliver the most advanced medical care for life-saving efforts on the sickest patients who are often caught by surprise and can be amongst the most vulnerable mentally and emotionally. The proposed decentralized vertical hospital will allow development of smaller more challenging sites, making the pool of potential sites less limited. The site selected is a small parcel of land with many site features that present obstructions and difficulties to building.

Figure 7. Common Technology:Cell-phones.

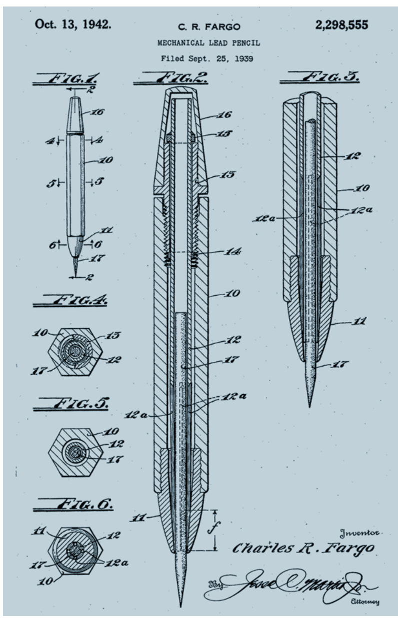

Figure 8. 1942 Patent for Mechanical Pencil.

Technology is the means which people use to improve their surroundings. It is a complex term and encompasses a broad base of knowledge that has been segmented into many different fields and which can be recognized in many different forms. When older generations typically think of technology, images of computers, space missions and other futuristic forms in the context of outer space may come to mind. The younger generations of today associate technology with cellular phones, wireless internet, Ipods or other conveniences that make lives more entertaining. Fundamentally though, the purpose of a technology is to achieve something useful and practical. The United States patent system was formed to protect those innovations, inventions, and designs and credit those in which these ideas originated. Some practical innovations are not necessarily associated with technology because they are viewed as commonplace. For example, the mechanical pencil, which had a patent granted in 1942, was a significant technological development of the time whereas today it is everywhere and is not viewed as such. In order to understand the significance and sophistication of a technology it should be framed by the time and context of it's develop-

Figure 9. New ergonomic mechanical pencil.

ment and widespread adoption. As with most technologies, there have been many variations and improvements, and hence new patents, to the mechanical pencil since 1942. Continually, humans will use their inherent ability to think and reason to devise and improve upon tools, processes and systems that make lives easier and more efficient.

Although technologies are generally considered useful and practical and enable life to be easier and more efficient, they sometimes can have negative impacts, cause poor results and be disabling. These situations where technology has unintended consequences presents a paradox. This paradox, in terms of the development of technology, needs to be addressed and, if possible, resolved before the technology can be considered ultimately beneficial. There have been certain pharmaceuticals recently that fit into this definition of paradox and technology. The drug Vioxx for example, which has been pulled from the market, has walked a fine line between beneficial and harmful. Once thought to be a promising and powerful medication to combat arthri-

Figure 10. Harmful Medications:.Vioxx by Merck.

Figure 11. Early X-ray of Hand by Roentgen.

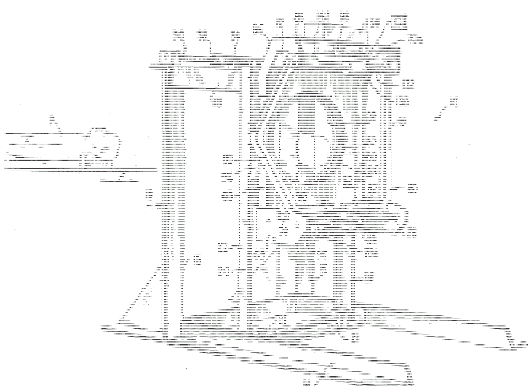

Figure 12. Early X-ray Machine Design.

tis, it has also proven to increase the risk of causing heart attacks and stroke. The seriousness of a technological paradox elevates when the negative consequences begin to effect health.

Modern health care, since nineteenth century, has paralleled and thus been heavily influenced by technological development since the industrial revolution. The X-ray, developed by the physicist Wilhelm Roentgen in 1895, is the quintessential example of technological experimentation later applied to medical use. The fact that this technology scattered harmful radiation did not go unnoticed and subsequently led to the development and refinement of a less harmful X-ray tube along with protective lead shielding that is still used today. The applications that followed Roentgen's discovery can be considered life saving. However, the example of the X-ray illustrates that certain life-saving discoveries dependent upon sophisticated technology sometimes produce unhealthy side effects. In the health care industry, technology can create a paradoxical situation because it can be, at the same time, both beneficial and harmful to people. As with X-ray, the negative effects of technology have been mitigated over time by adjustments to the medical equipment, medical practices and the medical settings in which these technologies can be found.

The Intent of Technology

Figure 13. Common Technology - From above: Walk-man, Computer Technology and Laser Technology.

Technology can be very simple or very complicated and includes technical methods, skills, processes, techniques, tools or raw materials. Just about everything we use or consume today was developed, assembled, machined, constructed or harvested with some form of technology. Suffice it to say that technology encompasses almost everything unnatural and can be employed to process and manipulate matter that is natural. Technology is defined as “the current state of our knowledge of how to combine resources to produce desired products, to solve problems, fulfill needs or satisfy wants” (Wikpedia Contributors). This “combining of resources” describes the development of a technology that is typically intended to achieve usable and practical results that improve the way people live. Technology can be found almost eveywhere in our society today and very rarely do we consider it superfluous or having no practical use. Many of our technological developments in the United States have a patent established for them in which the law specifies that the subject matter must have useful purpose (United States Patent and Trademark Office). Many older developments are not typically perceived as being technological at all because they are

Figure 14. The Primitive Stone Wheel.

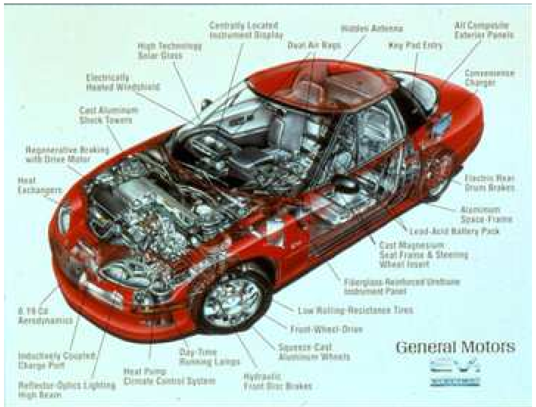

Figure 15. Complex Technology: The Automobile.

ordinary, familiar and commonplace today. The wheel, for example, is not generally associated with the common concept of technology today because it is easy to comprehend and more widely used. Most people classify complex things that are difficult to understand and take specialized knowledge to develop as being technological. The automobile, for example, is so complex to the point that it is rarely ever built by the common person and most opt not to understand the systems to repair it when damaged. The automobile is commonly regarded as being technological, yet it has been relatively familiar and a part of civilized society for over one-hundred years. Manufacturers keep advancing the design of automobiles, by computerization or improved energy efficiency, in order to meet the present demands of consumers. The automobile, as well as other technology, allows us to live easier and more efficiently.

As stated earlier, technology is defined as the "current state of our knowledge." The word "current" in this definition is important because in order to understand the sig-

Figure 16. Past Technology: Scalpels.

nificance or degree of complexity and sophistication of a technology it should be framed by the time and context when it was developed. What may seem technologically unremarkable in the context of today may, at the time of the development of this technology, have been considered highly complex and extremely useful. For example, in the ancient city of Pompeii, a number of surgical devices were discovered at "The House of the Surgeon." Among the tools were a number of scalpels that were used over 2000 years ago. These tools may have been significant technological devices of that time, but now are considered fairly common today. Contrast the scalpel to technologies now that are so advanced and complex that broad practical applications have yet to be determined. An example of such a complex application is nanotechnology. University of California-Berkeley scientists have developed an electrostatic motor that is roughly the width of a human hair, yet there are currently no practical applications for this technology (Sanders). It is anticipated though, that this technology will have a profound impact on medicine in the future by acting as a molecular scalpel that fights disease on the cellular level. Therefore, the best and most

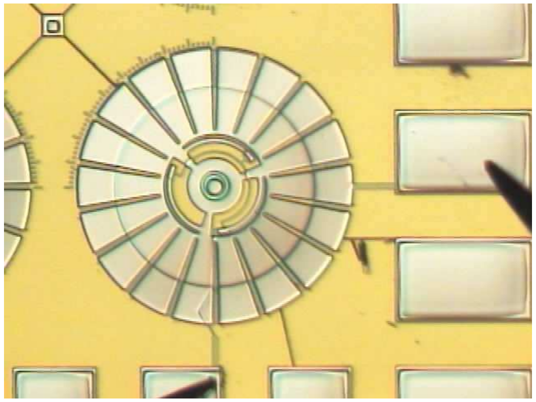

Figure 17. Future Technology: Nanotechnology and the Electro-static Motor

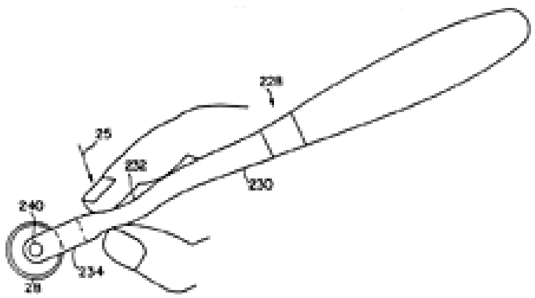

Figure 18. Rotary Scalpel: Improvements to the ancient scalpel.

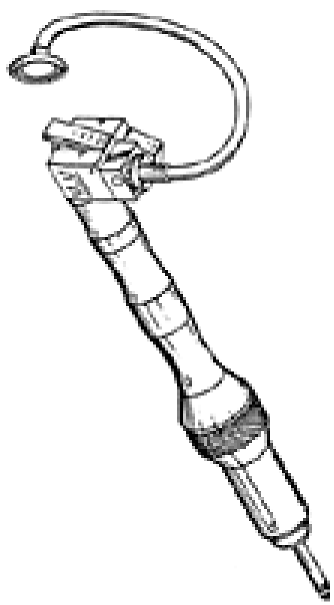

Figure 19. Powered Rotary Scalpel: Improvement on the rotary scalpel.

practical technologies are those that are useful and solve fundamental problems for broad range of people and a variety of applications over an extended period of time.

Technology broadly involves the use and application of knowledge to achieve a practical result. For a technology to be significant it has to be useful, meaning it has to have some kind of application to real life problems. Most useful technologies when they are first invented will try to obtain a patent. The United States Patent and Trademark Office will not issue a patent if a technology is deemed useless as the law states, “any person who invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent.” The example of scalpels and the electrostatic motor, used previously, are very significant and useful technologies that highlight the beginning and future of medical technologies. Current medical technology has one thing in common; knowledge was applied to achieve a practical result whether or not the technology was an invention or original idea or an improvement upon an idea that already existed.

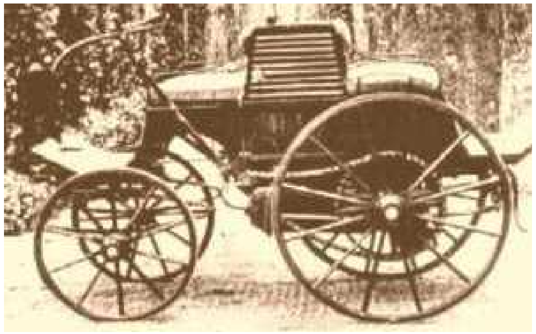

Figure 20. Early Car Technology: The Panhard, 1890.

Figure 21. New Car Technology: Toyota Camry, 2000.

There is continuous urge to improve upon existing technologies. Humans use their ability to think and reason to devise tools, processes and systems that improve lives by making them easier and more efficient. There is hardly a form of technology that has not undergone transformation since inception. A modern example of something that has undergone much change in a relatively short time period is the automobile. The first semblance of an automobile was developed by Nicolas Cugnot in France in the late eighteenth century. As the image shows, relative to the cars of today, it was a steam-powered, open-air, slow, loud and fairly dangerous machine. After more than 100,000 patents, the automobile of today has evolved into a relatively safe, fast, quiet, gas and battery powered vehicle. The automobile, in and of itself, has satisfied many wants and needs and has provided many benefits to the individual in society. Collectively though, automobiles have been associated with global changes which are not necessarily practical and have not always been considered an improvement.

Suburban sprawl, which is the rapid and expansive growth of a metropolitan area, is


Figure 22. Suburban Sprawl.


Figure 23. Los Angeles Smog.

an effect that is often attributed to the automobile. The automobile has contributed to the strain on our natural resources, particularly fuel oil and is also generally associated with Greenhouse gases and environmental pollution that has led to global warming because of the amount of carbon dioxide collectively emitted into the atmosphere. The excessive use of the automobile and the design of our cities have been linked to obesity and an overall unhealthy lifestyle (Frank, pg. 87-96). The automobile, which Americans have grown so accustomed to, has many benefits and is certainly an enabler, however it also has some dire negative effects and can also be disabling to our physical health.

The Paradox of [Disabling] Technology in Health Care

Figure 24. Physicians of Today Practice High-Tech Medicine.

The automobile was used as an example of a very practical technology that has many benefits as well as some negative impacts. These negative impacts effect, and continue to threaten, our environment and arguably our global health. There are also other technologies that are linked to impacts on health as well, such as factories, pesticides, television or even pharmaceuticals. Our own health care industry is not immune to this technological paradox. In many respects the life saving advances of modern medicine are dependent on sophisticated technologies, yet these same technologies can at times also produce unhealthy side effects on patients in health care settings. Norman Cousins, a writer affected by a debilitating illness, wrote a book about his experiences in the hospital and with modern medical care. He wrote of the “critical shortcomings” of the hospital, the dependency on medical equipment, excessive reliance on prescription medication, the impersonalization produced by new technology and his conclusion that the “hospital is no place for a sick person” (Cousins, pg 29). He does not argue for the destruction of all technology in the hospital, but lobbies the health care industry for a better balance of the implementa-

Figure 25. High-Touch Medicine of Old.

Figure 26. Predominant Use of Technology in the Hospital.

tion of 'high-tech' with the 'high-touch' practice of medicine.

Healthcare, from the end of the nineteenth century in industrialized nations and particularly within the past thirty years, has been highly influenced by technology. From the medical equipment used during procedures to the medical practices that are influenced by and utilize these devices to the design and construction of the supportive environments, advances in technology cause health care to continually evolve. This evolution is no more apparent in the debate of high-tech versus high-touch medical care and the medical profession's strong reliance on technology in the hospital. The common complaint from patients today is that the physician does not listen and relies more on computers, machines, X-rays, images, etc. to formulate diagnosis or treatment. In the early eras of medicine, before medical equipment was prevalent, the physician had to rely on senses, whether it be seeing or hearing, knowledge of the patient and medical history as well as the collective knowledge gained through schooling and experience. There were not always X-rays, scopes or physiological monitors that revealed hidden abnormalities. Abnormal heart rate was something heard instead of measured and broken bones, not obvious to the naked eye, were diagnosed by examining patients range of motion and amount of pain. There has been a new trend to seek out this old-world, high-touch level of care where the patient gains comfort by forging a relationship with their physician.

Despite the debate and trend toward high-touch over high-tech health care, one corrolary has remained consistent for the past one-hundred years. This period of time associated with significant technological progress in more modern societies, has also been associated with an era of significant progress with respect to mortality and morbidity. Although the scientific proof is not entirely conclusive, the facts suggest correlation between advancement in technology and progress in health. In the United States over the past century, the life-expectancy rate has nearly doubled from about thrity-six years in 1850 to seventy-five years in 2003 (Life Expectancy by Age). The infant mortality rate has decreased from a near sixty deaths per

Figure 27. Early Use of Stethoscope.

Figure 28. Use of the Endoscope Today.

thouand births in 1933 to approximately seven per thousand in 2002 (Kockanek). In the late nineteenth and early twentieth centuries, the gains in these vitals statistics have more correlation to awareness and practice of nutrition and sanitation than improvements in medical equipment and practices within the hospital. During the mid-20th century, these gains could be more attributed to widespread vaccination. Regardless, our understanding of, and ability to combat, health-related social issues was increasing concurrently with our development of new technologies.   For example, Jonas Salk could not have developed a vaccine for Polio without first witnessing the eradication of the virus through a microscope.   The detection of Tuberculosis was largely aided in the 1800s through use of the stethoscope and in the early 1900s by way of x-ray and was subsequently treated by antibiotics. These, with respect to modern medicine, are relatively primitive means in diagnosis and treatment of disease. Consider the advanced and sophisticated technology of today such as ventilators that mechanically push air and oxygen through the lungs or the use of fiberoptics in endoscopy to view internal organs through small openings in

Figure 29. Medical Technology and the Patient.

the body. Advances in technology no doubt has had a profound positive effect on health care and although the general intent is to improve life, it can sometimes be detrimental.

Technology, particularly where employed in life-saving efforts, creates a paradoxical situation because it can be, at the same time, both beneficial and harmful to patients. Norman Cousins claimed, in his 1979 book *Anatomy of an Illness as Perceived by the Patient* that, “Many doctors are increasingly aware of the circular paradox [of the intensive care unit]. It provides better electronic aids than ever before for dealing with emergencies that are often intensified because they communicate a sense of imminent disaster to the patient” (Cousins, pg. 133). Cousins was a patient himself inflicted with a long-term debilitating illness and spent long periods of time confined to a hospital bed connected to and monitored by life saving devices. What Cousins claimed from his experience in 1979 is still applicable today, over a quarter of a decade later in an industrial society with increased familiarity with sophisticated technology. An article on the evaluation of patient experience in the intensive care unit published in 1998 in *The Journal of the Society of Critical Care Medicine* concluded that patients with acute respiratory distress syndrome reported having extreme traumatic stress as a result of discomfort during time of stay. Unfamiliarity with the technology in the environment was among the distressing factors (Schelling, et al. pg. 652). Despite the traumatic experience these patients had, ironically, their overall long term health-related quality of life was reported as being good. It is during the short-term in which these patients experience enough stress that inhibits or prolongs the recovery process.

Figure 30. Patient Coping with Stress.

Technology can be disabling and create adverse health effects by inhibiting a persons' ability to have and to sense comfort and control. Adverse health effects, primarily stress, can be defined as physical, mental or emotional tension. Whenever we feel stress or tension in any way, our body automatically responds by producing excess levels of hormones in an attempt for the body to cope with a challenging situation. Depending on personality and predisposition to risk factors, people are affected by stressors in different ways. For one person, financial hardship may cause stress and yet for others, responsibilities at work or home may be the source. Often, stress can be caused by a perceived or real lack of comfort and loss of control. Control may be lost over a person's physical environment, or it can be from feelings of helplessness, distrust and of too much dependency on others (Longe). Also, excessive durations of stress have been linked to long-term health problems and chronic disease. Norman Cousins was able to improve his health in part by reducing his stress, empowering himself through learning about his illness, taking control of his medical treatment and ironically discharging himself from his hospital bed. He believed that his health could only improve by separation from stressors located within the hospital and those things that took away control; namely medical practices, medical equipment and the medical setting.

Historical Influence of Technology in the Medical Setting

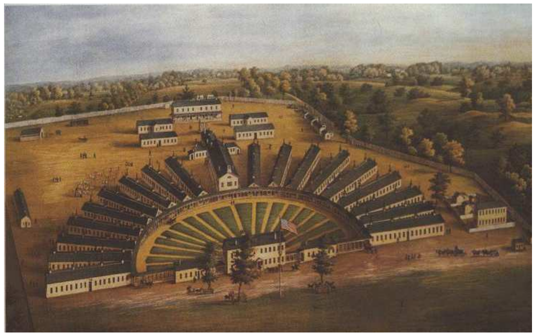

Figure 31. Pavilion Hospital.

The environment is typically viewed as being neutral and not necessarily providing positive or negative stimuli with respect to the physiology of the patient. This is the modern and technological response to the environment, but early hospitals exemplified that this was not always the case. Mid-nineteenth century hospitals played an active part of the healing process and medical care. The pavilion hospital, which consisted of a plan advocated by Florence Nightingale, was predicated on air movement and cross-ventilation to help rid the environment of germs and noxious air (Cohen, pg. 133). Declining death rates provided the evidence for continued acceptance of this prototype. The study of air movement and sanitation heavily influenced the pavilion plan of Henry Currey's St. Thomas' Hospital in London in 1870 (Cook, pg. 356). The design utilized complicated and technologically advanced ventilation stacks, mixing heated and cooled air, developed a formulaic response to daylighting, building footprint size, interior volume, building mass, height and separation with courtyards. It relied on lifts and chutes, separating soiled and clean materials. The pavilion concept influenced program requirements of nursing unit size

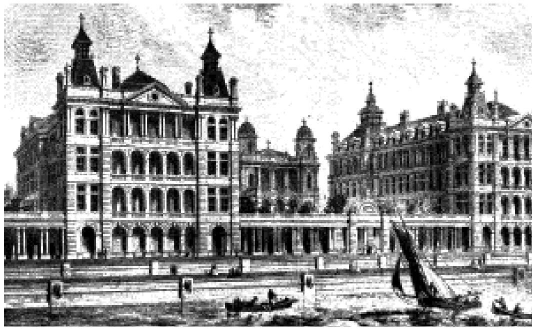

Figure 32. Perspective of St. Thomas Hospital, London showing rooftop vent stacks.

and the provisions for a laundry and kitchen that could provide for the basics of sanitation and nutrition. The pavilion design was to form the basis for architecture of hospitals for next four to five decades. It was also the precedent for Alvar Aalto's 1932 Paimio Sanitorium in Finland. Aalto claimed that the main purpose of the hospital, which treated tuberculosis patients, "is to function as a medical instrument" in which every detail was developed from the perspective of the patient (Schildt, pg 68). Here again, ventilation and lighting were of primary importance. Attention was given to the articulation and color of the ceiling plane as well as orientation to the window and views that a prone patient would see. Detail even extended to the lounge furniture which was designed to help ease the weakened breathing of the patient. The developments of the pavilion hospital and Aalto's Paimio concept of the hospital as a medical instrument, occurred some time before significant technological progress with respect to medical equipment and practices and the modern hospital.

As the twentieth century progressed, there were significant technological

Figure 33. Typical 20th Century hospital design: Nebraska Methodist Hospital.

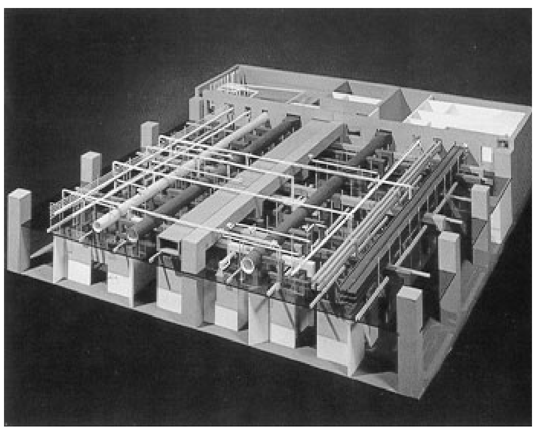

Figure 34. Advanced hospital engineering: interstitial mechanical zone.

developments in medical equipment and medical practices. The hospital, with the increase and separation of medical services, became more and more programmatically and technologically complex. The focus of hospital design shifted from the hospital as a healing mechanism to being a building that solved the programmatic and functional challenges of medical practices as well as accommodate the growing use of medical equipment. It is as if architects relegated all of the healing responsibilities to medical practitioners and technological devices. The results of hospital design in the mid-twentieth century have not been noteworthy. The typical design could easily be described as a tower block on top of a flattened podium, see Figure 33. This not to say that the building engineering, including mechanical, plumbing and electrical systems, did not make great strides forward in the development of technology and implementation within the hospital. In that respect, much was accomplished, but the focus on these building technological systems may have taken further emphasis away from the direct therapeutic role of the medical setting.

Although technology generally yields positive health outcomes, it causes adverse side effects when it negatively influences the therapeutic and healing potential of the medical setting. In their book published in 2000, *Health care in an Era of Radical Transformation*, Steven Verderber and David Fine describe some of the influences of technology on the modern hospital,

> "…a lack of natural ventilation, shrinkage of the window aperture, diminution of the total amount of glazed area, adoption of the hermetically sealed building envelope, dependence on artificial lighting over natural daylight and a de-emphasis on overall patient amenity were but a few technologically driven modern developments (Verderber and Fine, pg. 393)."

These technological developments were far from clinical and can hardly be described as having healing effects or therapeutic potential. The advances of technology on buildings during this period resulted in thick buildings that often lacked sufficient

Figure 35. Dark interior hospital corridor.

daylighting and proper orientation and thus caused confusing and confining spaces. They also lacked the natural ventilation so highly regarded in the pavilion concept, because outside air made it difficult to balance the mechanical systems. They were often finished with rather banal highly durable materials and colored white in order to appear more sanitary and easily cleaned. Hospitals were programmtically deficient, lacking in public, social or family spaces that allowed for the stress reducing distractions which help formulate the mental and emotional therapy that people need. In the last twenty years of the twentieth century, the traditional approach has been to decorate medical settings in an attempt to compensate for the negative image and impact of technologies. Hospitals were no longer viewed as simply sterile boxes, but the focus on the complex technologies and practices remained contra-therapeutic and disabling, taking away the patients' comfort and control.

The goal of the modern hospital was to improve conditions for medical care to take place, creating flexibility, allowing for equipment and practices within treatment spaces, improving staff movement as well as the handling and distribution of supplies and materials. These planning concepts could be attained, but it was often done at the expense of the patient who was viewed as ancillary to all of the needs of medical equipment and practices.

To be effective, medical settings must accommodate needs of technology but when this is the only focus, the environment can be disabling by taking away comfort and control. It has already been demonstrated and explained how comfort and control can be taken away from the patient through disabling medical equipment and medical practices, creating unhealthful effects. The negative impacts of technology on the modern medical setting have been described as well. Studies have shown that stress resulting from these negative environmental stimuli can have profound impacts on the patient and their health outcome as well.

Conclusion

Technology is a vast and complex entity that has been very influential in modern society and in the health care industry in particular. Although the intent of technological development is to improve lives and health outcomes, it sometimes unfortunately causes adverse consequences. This situation presents a paradox that the health care industry has accepted because of the widespread benefits that technology has afforded humankind. As a statistic, innovative and technological development in modern medicine has paralleled overall positive health trends. The number of good outcomes and health experiences far out-weigh the negative and detrimental. Yet, this is not to indicate that the negative experiences are ignored or downplayed. Health care providers are actively seeking ways to deal with these paradoxes. The issue for this thesis is whether they are dealt with adequately, and can the benefits of technology be utilized with fewer side effects for patients in tertiary care settings.

In order to effectively deal with the paradox, the origination of how the paradox operates must be defined. In the case of the negative outcomes experienced in a health care setting, there are three main forces acting upon the patient which are heavily influenced by innovation in technology that help facilitate operation of the paradox and the resulting negative side effects. These forces are medical equipment, medical practices and the medical setting. Each one has their enabling benefits and their disabling effects with respect to technology but most important is how each has dealt with the negatives and done their part to help resolve the health care – technology paradox.

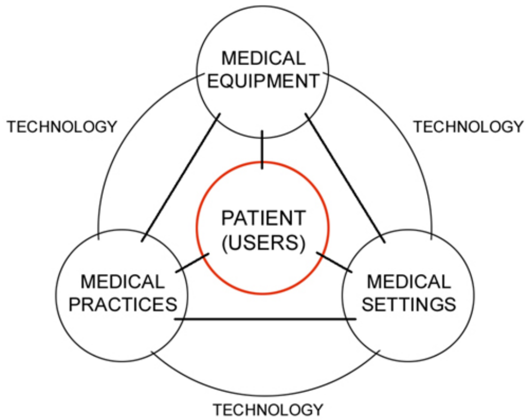

Figure 36. Health care - Technology Paradox Paradigm.

Figure 37. Medical Equipment, Practices and Settings in a total environment

As stated in the previous chapter, there are three main forces acting upon the patient that are heavily influenced by innovation that help facilitate operation of the paradox and the resulting negative side effects. These forces are medical equipment, medical practices and medical settings. When technology, operating through medical equipment, medical practices or medical settings, negatively influences the patient, the paradox activates and the health care experience is compromised. The Health-Care Technology Paradox Paradigm in Figure 36 shows diagrammatically that technology, which is the common influence amongst the three factors, encompasses equipment, practices and settings, which are implemented to provide a positive impact on the long-term life of the patient. Medical equipment are those physical instruments that sustain life and are implemented in medical practices. Medical practices are those procedures necessary for care giving to occur, which are aided by medical equipment. Medical settings are those places that contain and interface with medical equipment and are highly functional, having significant requirements placed upon them to support medical practices.

Figure 38. Tertiary Care: Trauma Room.

Figure 39. Ryder Trauma Center: Miami, Florida.

The most significant settings where the paradox occurs are tertiary medical centers. Tertiary medical centers are facilities that are generally larger, cover a wider geographical region and have services provided by specialists equipped with diagnostic and treatment facilities not generally available at local hospitals. Facilities that provide special investigations and treatments typically have trauma centers, burn centers, neonatology units, transplant and oncology services. They contain the most sophisticated medical equipment, demand and deliver the most advanced medical care to the sickest patients who have longer hospital stays and yet still may be aware of their surroundings. At the local hospital level, the closest services to a tertiary care level would be found in the intensive care unit or the emergency trauma room. The patients in these environments are typically the least comfortable, capable and able to cope with stress.

While the long term outcome of the patient in these tertiary care settings may ultimately be positive because of the life-saving advances of modern medicine and medi-

Figure 40. Intensive Care Unit Patient Room.

cal technology, in the short term, the patient experience of medical practices, equipment and settings can be debilitating. As cited in the first chapter in *The Journal of the Society of Critical Care Medicine*, patients with acute respiratory distress syndrome reported having extreme traumatic stress such as discomfort, anxiety and pain during their stay within the intensive care unit. Another article in the *Canadian Medical Association Journal* discusses the "promise and the paradox of technology in the intensive care unit." The argument is made that the use of the ventilator and balloon pump in the I.C.U. is prolonging life while not necessarily improving the quality of life (Cook, pg. 1118). Although technology generally yields positive health outcomes, it causes adverse side effects when it negatively influences either the healing and aesthetic impacts of medical equipment, the administration of medical practices and the therapeutic and healing potential of medical settings. In Cousins' experience, what was disabling about the technology was it communicated a potentially negative outcome. It was the infamiliarity of his situation as a patient that caused the stress and discomfort. Patients' will be comfortable and desire technology when it is perceived to be enabling and will be uncomfortable and reject it when it is perceived to be disabling.

Patients and Enabling Technology

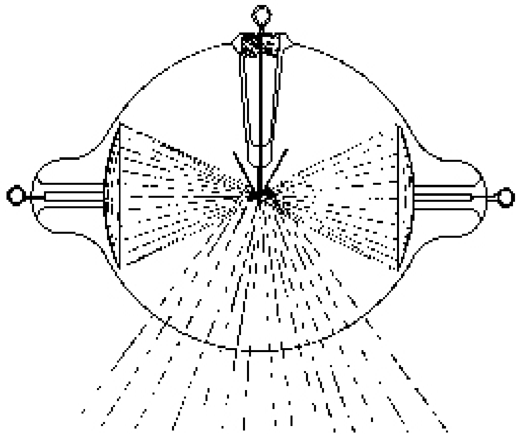

Figure 41. Diagram of Scattered Radiation from X-ray.

Figure 42. Surgical Suite.

The health care industry has to continually monitor, study and research the performance of medical equipment implemented in the hospital. Before medical equipment is brought to the market and sold to physicians or hospitals, the device must first be proven to be worthy of use during clinical trials. Sometimes the device may be proven effective and useful without fully knowing all of the long-term effects such as the early X-ray machine that caused scattered radiation. Understandably, sometimes these pieces of medical equipment are found to be faulty, or cause patients harm during usage. Although sophisticated medical equipment has historically been beneficial, improving upon older technologies and increasing quality of output mitigates adverse health effects on the patient and is more enabling.

Throughout the history of modern medicine, the development of medical equipment has enabled positive health outcomes for patients. Nowhere is this more relevant or significant than in those medical settings such as the surgical suite, the trauma room, or the intensive care unit. The reason is because these environments have the most

Figure 43. I.C.U. Bedside Procedure.

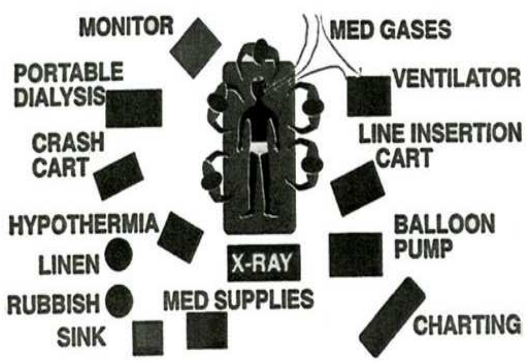

Figure 44. Diagnram of I.C.U. Bedside Arrangement.

intensive medical equipment, coupled with the strictest of medical practices, protocol and procedures. In these environments, each piece of technology has its specific location and each person has their specific position where they need to be just in case things take a turn for the worst. In fact, many states regulate who and what needs to be at the bedside and outlines the responsibility of each.

The intensive care unit patient room is an example of a setting with sophisticated medical equipment that provide life-saving value for the patient and influences both medical practices and the medical setting. Intensive care unit equipment includes patient monitoring, respiratory and cardiac support, pain management, emergency resuscitation devices, and other life support equipment designed to care for patients who are seriously injured, have a critical or life-threatening illness, or have undergone a major surgical procedure and thereby require twenty-four hour care and monitoring. The illustration in Figure 44 depicts a typical arrangement of equipment in an I.C.U. that cares for patients with a broad range of illnesses. Some equipment has consider-able physical mass such as ventilator, balloon pumps and dialysis machines, which have been a traditional part of the I.C.U. for decades. The ventilator allows respiration for those patients who are unable to breathe on their own. It prevents death and prolongs life and is ultimately beneficial for those who are not frail and weak prior to the onset of a traumatic event. The balloon pump is another life saving device that helps reduce the workload of the heart and helps blood flow. However, as beneficial and life saving as these devices are, they can also have disabling health effects that hinders the healing process with respect to both the physiology of the patient and with the design of the physical environment.

Figure 45. Patient in an I.C.U.

Although technology generally yields positive health outcomes, it can cause adverse side effects by negatively influencing the physical, emotional and mental states of patients. The amount of medical equipment needed for life support previously illustrated in the I.C.U. room can make a person very uncomfortable with their situation. Imagine being home, possibly watching television, not feeling well one evening and com-

Figure 46. I.C.U. Room and Equipment.

Figure 47. Patient on a Ventilator.

plaining of chest pains. Then, because of a lack of blood and oxygen to the heart, you suddenly have trouble breathing, grow weak and eventually collapse. Then, imagine awakening to the sight of a hospital room, much like the photo in Figure 46 surrounded with unfamiliar people who monitor machines that have control of many natural body functions. This is the paradox that Norman Cousins describes, "electronic aids…dealing with intensified emergencies…communicating imminent disaster." This is the psychological impact of medical equipment however, the physical impact can sometimes be worse. The ventilator for example can be very discomforting to a patient. Despite the undeniable benefits this machine has, studies have proven that mechanical ventilation can cause "physiologic and structural lung damage" that have a profound effect on the length and quality of the remainder of a patient's life (Cook, pg 1118). Recently, there have been studies of the long-term negative effects that machines such as these cause. In the short-term, this technology compensates for the disability of the body but does little to strengthen it for the long term.

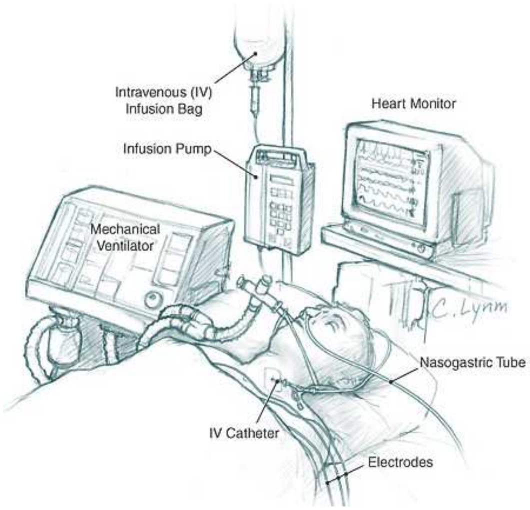

Figure 48. Typical I.C.U. Equipment Arrangement.

Figure 49. Patient in an I.C.U.

Furthermore, intensive medical equipment such as the ventilator and other deviecs in the I.C.U. environment have a great impact with respect to size, arrangement, sound and aesthetic. Because of the size and function of some pieces of equipment, they are required to be in certain positions with respect to the patient. The best position for the ventilator is by the head and the same can be said for patient monitors. This equipment can be restrictive for the patient, discouraging flexibility and movement. Also these pieces of equipment placed by the head of the patient can be noisy. The ventilator makes percussive sounds and the monitors can have a pulsating beeping noise. This equipment, along with the noises, blinking lights and proximity to the patient create what Jain Malkin describes as a "Twilight Zone" atmosphere that can be disorienting and not reassuring (Malkin, pg. 219).

Manufacturers of medical equipment are improving upon older technologies to improve medical practices and minimize patients' medical complications as well as mitigate negative side effects. The ventilator, for the physical problems it causes to

Figure 50. Iron-lung Therapy Room.

Figure 51. Patient with Mechanical Ventilator.

patients has come a long way from its early predecessor, the iron lung. In the 1920s, the iron lung, which induced ventilation by compressing and decompressing the body, was fairly large and greatly restricted patient movement. Ventilators from the 1950s employed mechanical ventilation much like today, however these lacked monitoring and regulation of the force with which this pressure was delivered. This pressure was causing lung damage. Even though the devices of today, when used incorrectly can still cause damage, they are computer-controlled and function in complex ways to produce ventilation that closely matches patients' breathing needs. Additionally, newer non-invasive ventilators no longer have to be inserted into the throat and allow oxygen through a face or nose mask. These newer technologies are more efficient and require less effort and enable less respiratory work on the patient's part and de-creased workload of the muscles that assist with breathing. They also allow for the patient to communicate through speech. The F.D.A. regulates machines such as the ventilator to ensure that the devices are safer and more effective (Kurtzweil). An added benefit to the improvement of medical equipment is that often these technologies become more physically compact, more flexible and have less impact on the environment. They also allow for improved and more efficient medical practices to occur.

Medical Practices and Enabling Technology

Figure 52. Intensive Medical Practices.

Medical practices are those procedures necessary for care giving to occur and include protocols, processes, examinations, treatments, procedures as well as operations. Those practices which are the most technologically intensive occur in environments such as surgical suites, post-anesthesia care units, imaging, emergency or trauma, cardiology and various types of intensive care units. Any time a patient undergoes medical treatment, there exists the potential for negative side effects due to the nature of medical practices and the degree of sophistication, both technological and procedural. There are too many variables and factors in any medical procedure for the health outcome to be routine, predictable and without complication. There is the severity of the illness and overall age and health status of the patient, sophisticated medical equipment, tools and devices, infectious bacteria, and anesthesia or other pharmaceuticals. In order to deal with these complications, a team of highly skilled physicians, surgeons, nurses, technicians and a planned environment is organized around providing optimal hospital functional relationships. As stated previously, manufacturers of medical equipment continually advance their products to respond to new procedures and to minimize the cause of negative impacts during treatment. Like medical equipment, medical practices have ultimately improved health outcomes and providers have realized that by improving techniques, negative health impacts as a result from technologically sophisticated procedures can be minimized.

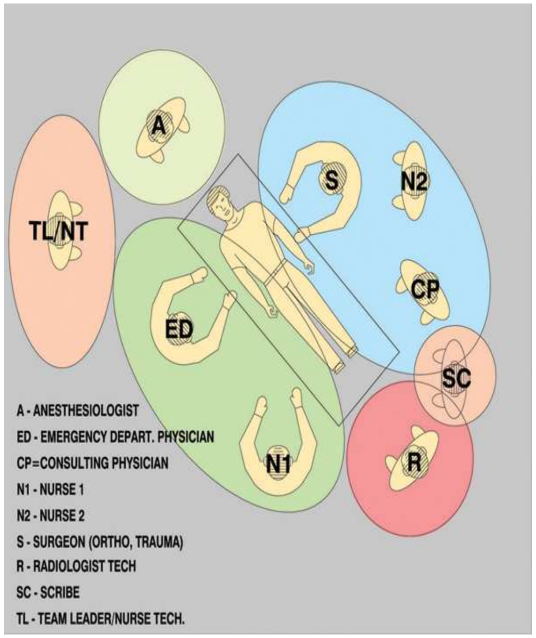

Figure 53. Typical positions of trauma room clinical staff.

The previous section indicated how intensive medical settings, such as the trauma room or the surgical suite, had the strictest medical practices, protocols and procedures. Each person in these settings has a specific position and responsibility to fulfill. These standard operating procedures have been developed, studied, debated and refined over periods of time and always adjusted with new breakthroughs in technology. No matter the technological developments of these procedures, they should always be for the benefit of the patient. Many physicians oaths are similar to what Hippocrates wrote in his book *Of the Epidemics*, "Declare the past, diagnose the present, foretell the future; practice these acts. As to diseases, make a habit of two things; to help, or at least to do no harm (Markel, pg. 2026)." However, there will always be risks as the these procedures grow more and more complicated and will continue to have the potential for short term harmful effects.

Figure 54. Heart Surgery.

The original and intended purpose of the practice of medicine has been to cure the sick to the best ability possible, and with the assistance of recent technology; there is an even greater ability to provide better health outcomes. Physicians have developed complicated procedures that use medical equipment in order to repair, restore and perhaps replace damaged parts of the body. Medical practices such as surgeries are very technological in nature and have enabled life to be sustained, whereas in the past certain illnesses and injuries may have been deemed terminal. Many of these advances of modern surgery, including anesthesia and antibiotics, were developed during wars where patient's wounds would be fatal without surgical intervention. Heart surgery has been linked with careful study, sophisticated knowledge and advanced technology. Early on, surgeons practicing open-heart procedures needed to learn how to slow the beating of the heart, stop blood circulation, overcome infection and fight organ rejection. Heart surgery has enabled repairs to tears and holes, valve replacements, artery bypasses or heart transplants. Technology has assisted in overcoming what would have been eventual death without these procedures but has created pain and suffering until the patient can recuperate fully. The physiological impacts are harsh. New technologies are actively being employed today to reduce invasiveness of the procedure and the resulting degree of pain and time associated with recovery.

Figure 55. Recovering Patient in the ICU.

At later stages of an illness, patients were subject to the most traumatic and technologically sophisticated of procedures, open-heart surgeries being among them. Although technology is an enabler that generally helps yields positive health outcomes, it can facilitate medical practices that have adverse side effects on the patient. Surgeries such as open-heart can cause tremendous pain and can be very debilitating, causing physical weakness, internal discomfort as well as infections and nosocomial diseases. A patient is extremely weak following surgery and is further mentally disoriented as a result of medications, anesthesia and other life-supportive devices. Dur-

Figure 56. MRI Assisted Surgical Suite.

Figure 57. Imaging Guided Surgery.

ing recovery, there is continued soreness, discomfort and weakness and, for up to two months following the procedure, which can be very restricting for the patient. Physical activity is kept to a minimum and often life-style changes are necessary (Clark, pg. 50). This is the nature of the procedures that have been made possible through technology. Because of these harsh impacts, physicians have recently developed more advanced procedures that are less invasive and destructive to the body.

When surgeries, after the development of anesthesia, were in the early stages of development they were no doubt a traumatic and life-changing event. Before the beginning of the MRI or the CT, surgeons often had to use surgery in an investigative or exploratory nature to compensate for what technologies like the X-ray could not show. The risks associated with this were tremendous. After the MRI and CT were developed, it minimized this type of surgery because these technologies enabled physicians to analyze images of the soft human tissue that previous devices could not. They also led to the early detection of disease or abnormality that could be corrected

Figure 58. Cardiac Catheterization: Minimally Invasive Procedure.

without complicated surgery. Devices such as these eliminated much pain, discomfort and weakness and help develop a new trend of minimally invasive procedures. These newer procedures are often performed through tiny incisions with the aid of microscopic cameras and imaging devices. In cardiac care for example, physicians are able to use the veins and arteries as a conduit to access the heart. Valves can be repaired and blockages of the arteries can be removed. These procedures require less sedation, less invasion, less pain and long-term discomfort, which are quicker procedures and allow for faster recovery. Medical practices and medical equipment are helping relieve the problems associated with the health care – technology paradox.

Disabling Technology in the Tertiary Care Environment

Figure 59. Design is Typically Centered Around Technology.

Medical settings can also produce negative effects and can be disabling to patients when design is focused only on providing for the extensive needs of technologically and functionally advanced medical practices and equipment. Although often supportive of medical practices and equipment, the design of medical settings is not always beneficial and can sometimes be disabling and contra-therapeutic. Medical settings have utilized technology to primarily be more supportive of the medical equipment and procedures it contains, while not necessarily addressing patients basic essential needs of comfort and control. The most significant settings where this paradox occurs are tertiary medical centers where the most advanced medical care is delivered to the sickest patients who have longer hospital stays and yet who are aware of their surroundings.

The modern hospital settings in which these life-saving events take place has generally been neutral, neither significantly contributing to the paradox nor providing much relief. They are typically designed only to accommodate the most demanding medi-

Figure 60. ICU Headwall Designed to Accommodate Medical Equipment.

cal equipment as well as highly functional medical practices. In Anatomy of an Illness, Cousins contends that the medical equipment of an I.C.U. emit a sense of the lack of security to a patient and cause emotional strain (Cousins, pg. 132-133). He also writes chapters about the power of good doctors and holistic medical practices as well as the depressing routine of hospital life. But, Cousins does not directly mention the influences of the physical environment in which the patient and these “electronic aids” are contained.

Figure 61. ICU Patient Room: Open to the Corridor for Staff Access.

The intensive care patient room is an example of a setting that is often neutral. The room typically consists of four walls of which one typically opens wide, with double glass doors to the adjacent corridor for better views and access for nursing staff. The footwall, the wall that the patient sees the most, typically has a television and a side chair for visitors. The headwalls are usually extensive because they are occupied with medical equipment, gases, intravenous bags, etc. and staff access to the patient’s head is imperative in case of an emergency. The sidewall contains the code-required

Figure 62. Typical Open ICU Room: “Prisoner’s Cell.”.

window, but the patient is not usually oriented to this window because of the need for medical staff observation. The medical care of the patient and treatment of disease is important, but the ability of the environment to heal and be therapeutic is often sacrificed. Mayer Spivack claimed that “to enter a hospital either as a visitor or patient is to encounter an environment which has no equal in barrenness anywhere in our culture save for the prisoner’s cell” (Spivack, pg. 21). Intensive care settings are designed to employ technology in their systems, house technology as moveable equipment, and they provide adequate space to support the processes, equipment and gear necessary for treatment and diagnosis. This is the modern and technological response to the environment that is typified by the I.C.U.

In the I.C.U., there is often the assumption that the patient is either unconscious, unaware of surroundings or possibly too sick to be impacted by their environment. However, there is clinical evidence that suggest humans unconsciously register environmental variable effects on the nervous system – heat, light, noise, smells, tactile

Figure 63. View of Artificial Window and Daylight

Figure 64. View from Patient Room.

sensations, and our perception of movement and spatial orientation arising from stimuli within the body itself (Eberhard, pg. 4). There have been a series of well-publicized studies by Roger Ulrich that measure beneficial physiological effects of natural light, views of nature and visual stimulation (Ulrich, pg. 420-421). In one study by Ulrich involving open-heart surgical patients, it was discovered that visual exposure and stimulation to nature facilitated recovery from brain injury associated with surgery involving a heart pump. Other similar studies performed by Ulrich found that visual stimulation can relax blood pressure, brain activity and stress hormones (Ulrich, pg. 420-421). There is also evidence that suggest stimuli such as noise, excess light, lack of privacy can elevate levels of stress in the body to the point where it negatively affects the physiology of the patient, can extend length of stay in the hospital and increase the need for pain medication (Ulrich, pg. 420-421). The effect of the environment and the impact of technology on comfort and control is more than just the physical stimuli we notice, it also mental as well as physiological.

Conclusion

There should be a variation of a Hippocratic Oath in which designers and architects are sworn to use the body of knowledge gathered by clinicians and researchers to improve the design, and thus the performance, of the medical setting. Medical practitioners and some manufacturers of medical equipment have used a similar body of knowledge and evidence to influence the direction in which their professions are taken. As the body of scientific evidence on the design of health care settings grows, architects will better understand how their designs are critical to the health and well being of humankind.

Architects have little choice but to accept the role and influence of technology in the medical setting. The complex and ever-changing physical and functional demands of medical equipment and medical practices will always need to be accommodated in the future design of hospitals. Although sensitive medical practices and therapeutic medical equipment can be very influential on patient comfort and control, throughout the life of a hospital they are less constant with respect to technology than the medical setting. When medical practices and medical equipment are unable to fully address the concerns of comfort and control, the medical setting can help temper the paradox and the total impact technologies have on the patient.

ENABLING TECHNOLOGY AND HEALING ENVIRONMENTS

Enabling technologies can be employed in hospital settings to optimize comfort and control, reduce stress and create more therapeutic environments for patient care.. These enabling technologies will need to create a reassuring and calming environment that supports healing in all dimensions. This thesis focuses on mitigating the unhealthful effects associated with three primary aspects of the patient milieu impacted by disabling technologies: medical equipment, medical practices and medical settings. In a broad sense, technology can result in disorientation, inflexibility and confinement. By addressing and reconciling these issues architecturally, the negative impact of technologically sophisticated medical equipment and medical practices can be tempered, and consequently help compensate for the health care – technology paradox. In addition, the design of the medical environment should revisit some of the healing and clinical advances associated with buildings that led to dramatic declines in mortality rates in the early twentieth century, such as air movement, cross ventilation, day lighting, building footprint size and massing.

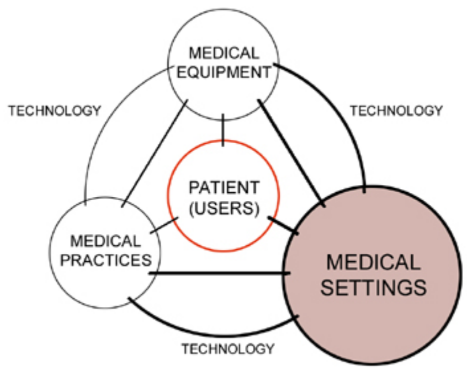

Figure 65. Medical Settings and the Health care - Technology Paradox Paradigm.

Architecture alone cannot be completely responsible for, nor can it completely reconcile, the healthcare - technology paradox. The diagram at the right illustrates that the design of intensive medical settings should compensate for the negative impacts of technologically evolving medical practices and equipment by addressing patients' experiential needs through the appropriate architectural accommodation of enabling technologies. In order to be considered healthful, these enabling technologies should provide the patient in the medical setting increased comfort and control. And, to provide for increased comfort and control, architecture can address the paradox by generally being reassuring and comprehensible, engaging and stimulating, and providing flexibility to allow for change. At the same time, it must do this while generally providing a therapeutic environment and effectively accommodating medical equipment and practices. The following sections of this chapter will identify these architectural accommodations and how they compensate for the negatives impacts associated with technology.

Environmental Optimization and Architecture as Clinical Instrument

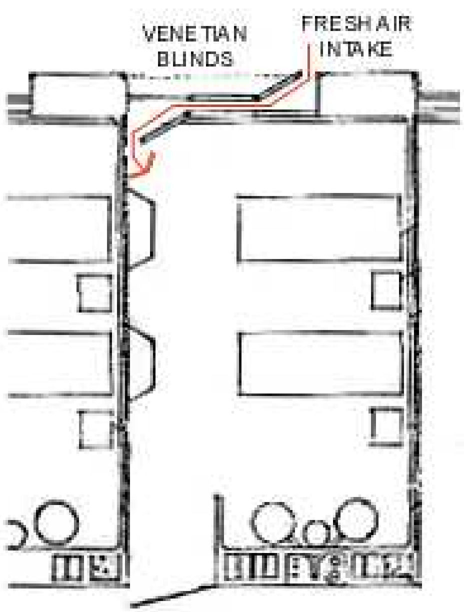

Figure 66. Paimio Sanatorium: Patient Room Plan showing operable windows and ventilation.

A healing environment that provides for comfort and control should employ technology to enable personal optimization of the environment. As discussed previously, modern technology in the hospital has taken early twentieth century architects from a light-filled, well ventilated, breathing building to an environment that is hermetically sealed, relying on artificial light and recirculated air largely controlled by medical staff and regulated by building automation systems. As the hospital evolved from the simple ward to a complex building filled with various departments, it became very important for mechanical systems to regulate temperature, humidity and light that was critical for procedures and maintenance of medical equipment. The amount of heat produced by computers, equipment, people and mechanical systems (steam lines, transformers, etc.) was difficult to overcome with passive ventilation and outside air. In addition, some procedures such as surgery relied on colder temperatures to minimize patients breathing, heart rate and potential for blood loss. These artificial systems translated to the entire hospital, partly because the technology was available. It was perceived as beneficial to the inhabitants and over the long term it saved money

Figure 67. Hospital with small windows and a sealed building envelope.

by maintaining a facility-wide balanced system. However, while these systems provided for the general needs of technology, the amount of control any particular patient had over the climatological aspects of the immediate environment was sacrificed.

Hospital buildings have complex mechanical systems that may still harm occupants as a high percentage of the total building air is recirculated and redistributed. At the extreme end of the spectrum, hospitals that are sealed and rely on mechanical systems may be subject to a greater risk of “sick building syndrome.” Hospitals are highly subject to this, not only because of ill patients and recirculated air, but also because the potential for water damage and mold growth is high (Nordstrom, et. al., pg. 683-688). Hospitals finishes are typically synthetic and may off-gas volatile organic compounds and cleaning agents used by housekeeping personnel can have powerful and caustic vapors. Also, continuous renovation and repair constantly create fine dust particles. Higher humidity levels in the hospital spawn bacteria and viruses, and the position of mechanical air intakes that do supply fresh air into the hospital are some-

Figure 68. Hospital air filter with mold.

times located too close to building exhaust fans, outdoor smoking areas, loading docks or helipads (Brownson).

At the same time, not being able to adjust and personally optimize an individual's immediate environment can present lack of control issues. Kenneth A. Wallston studied the potential for correlation between control and health and concluded that, "a lack of control can act as a stressor and have a direct, negative effect upon one's health" (Wallston, pg. 218). Also, in a 1999 article in the Architects' Journal, studies of windows in buildings have shown that "personal control is the single most important factor underlying comfort" (Leaman, pg. 38) and that perceptions of control are linked to health and productivity (Bordass, pg. 17).

Figure 69. The Intelligent Workplace™.

The Intelligent Workplace™, at Carnegie Mellon University in Pittsburgh, which is a multi-disciplinary research and study effort of advanced building systems and integration, focuses on measuring the environmental comfort, satisfaction and health for the individual user. Workstations within this space "give each occupant the ability to control thermal, visual, acoustical and air-quality characteristics of their micro-environment" (Schmertz, pg. 153). There are also controls available to vary acoustical privacy. Environments such as those at Carnegie Mellon utilize technology to enable control and comfort and create an environment that is healthful.

Technologies such as those in the Intelligent Workplace should be implemented in the design of medical settings because they can afford control to recuperating patients. If these controls are simple to use, as with the touch of buttons similar to the most common audio-visual technologies, and result in a direct and immediate response for the patient, the ability to for control could effect the mental state of a patient as well as their physical comfort. The patient could have total control over the patient environment much like in "Smart" home environments today. Patients could have control over visual and acoustical privacy, amount of daylight or artificial light, amount of airflow, air quality or temperature as well as technology they currently have control over already, such as nurse call, staff assistance, television, internet, food service, etc. Technology such as this is enabling and therapeutic and is very applicable to the critical care environment where patients are psychologically struggling with the lack of control and the potentially discomforting environment of the I.C.U.

Configurability and Setting Diversification

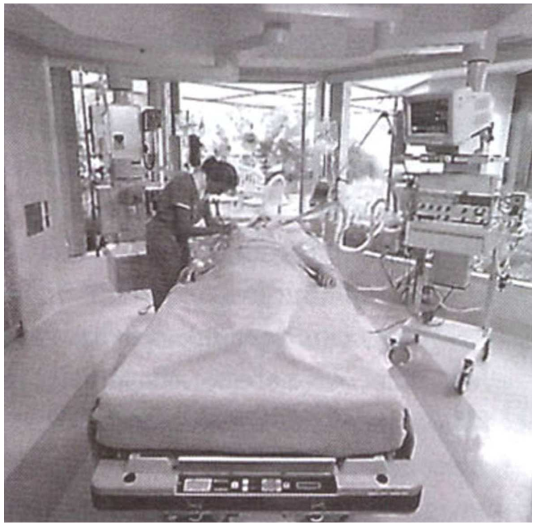

Figure 70. Overhead equipment boom that allows reconfiguration of patient room.

Mayer Spivack wrote in *Archetypal Places* that, "environments are restricted to a severely limited range of settings in which to carry out all of the behavior that constitutes the human repertoire" (Spivack, pg. 44). Humans have diverse physical, psychological and social needs that are typically carried out on a daily basis and in the intensive care patient environment this need is no different. People work to be productive, socialize to build relationships, engage in recreation to release energy and rest to recuperate the mind and body. Typically, the settings in which each of the activities take place differ in order to accommodate a particular function. In our own homes, we have the ability to move from room to room to vary our setting; offices are for study, living rooms are used for socialization and bedrooms are used to rest. Most hospital patient rooms are not designed to have multiple rooms like a house. Therefore the diverse functional needs of humans typically occur within a single room. In order to provide for setting diversity, this one room should be designed with the flexibility to accommodate different configurations. This flexible room must also be designed and equipped to provide for reconfiguration through use of technological devices such as movable walls or panels, windows or furniture. In a patient room that allows different settings, being able to provide for a patient's physical, psychological and social needs can be therapeutic.

Medical settings have traditionally been designed to be flexible so that a facility can physically grow, incrementally add services and adjust to unforeseen change. Flexibility can be designed for in different ways and usually consists of a regular and predictable structural system, extra capacities for horizontal and vertical expansion (from a site, structural, mechanical and electrical perspective), strategic location of easily alterable "soft" space as well as appropriate interior and exterior space planning and departmental arrangement conducive to growth. Flexibility, configuration and re-configuration should be accommodated for the benefit of the patient and not only for medical equipment and medical practices. A healing environment should provide for comfort and control by implementing technology to enable a variety of spatial configurations that accommodate diverse activities over the duration of a patient stay or

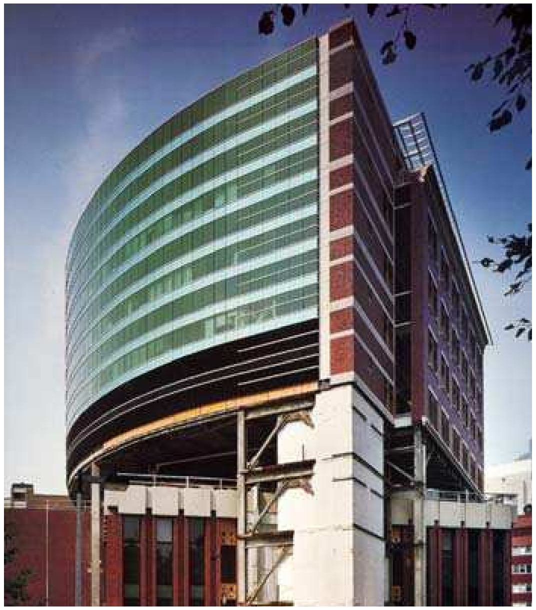

Figure 71. An inflexible and outdated structure that had to be built around.

the longevity of the patient care setting.

Flexibility, with respect to facility planning and unpredictable growth, is a basic necessity in the design of health care architecture. At any given time, new specialties may require new building services and infrastructure. Governments can change reimbursement rates for medical care rendering a particular hospital service unprofitable and undesirable. Insurance premiums on newer, more challenging and dangerous procedures could escalate, causing a facility to evaluate whether or not a particular service is worth the risk. Frequently, new technologies such as wireless networks or integrated digital imaging and videoscopy are required to provide for more communication and deliver better medical care. There are new modalities that are marketed or upgrades to old modalities that are faster, have better output, are more efficient and deliver clearer and better results. A hospital without an adjustable framework that does not allow for easier transitions will not yield a therapeutic environment over time for its occupants. Poorly planned facilities will delay progress, inhibit rollout of new technologies and services to the patient population and impede growth of services in high demand.

Flexibility that enables the configuration and the reconfiguration of space can allow the user to control and constantly adapt surroundings to meet both the changing and timeless human needs described earlier. Among those needs in the health care setting are privacy and solitude, socialization and interaction, education, consultation, activity as well as recovery and healing. Often, patients are confined to a single room that do not provide for the patterns that create a healing environment. The design of these spaces are typically focused on meeting clinical needs such as treatment, therapy and examination. Throughout any day, patients are subject to intrusions out of their control. Nurses and physicians continuously monitor the condition of the patient, lab workers take blood and other biological samples, caseworkers ask questions, families and visitors drop by and orderlies do transfers. The patient has to eat, rest, socialize and receive medical care all within the same setting.

Figure 72. Patient tethered to the wall.

Figure 73. Patients are often positioned for access by staff.

As a patient progresses from an ill condition to a more healthful condition, a room that is configurable should allow them to alter their immediate environment to satisfy variable physical, psychological and social needs. Hospital rooms, particularly patient rooms, can be amongst the most inflexible spaces. The patient is typically tethered to the headwall because of medical gasses, monitor leads, dialysis or intravenous fluids. There is usually medical equipment, such as ventilators, pumps or dialysis machines clustered around the head of the patient that are obstructive and cumbersome to move. When architects design facilities, they typically involve hospital staff and seldomly meet with patients to discuss their issues and needs. The result is an environment that is tailored to staff use, convenience and efficiency that are all important criteria, however this along with accommodation of medical equipment is typically the only focus. In the medical setting, this translates to the design of a room that places the patient furthest from the window, nearest the corridor in direct view of the nurse station, under artificial light, with little connection to the outside world. This amounts to the least private, loudest and an uncomfortable position.

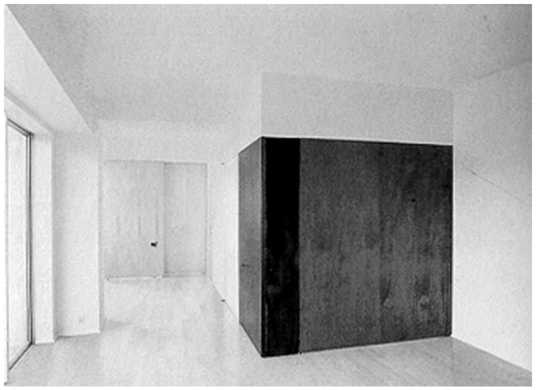

Figure 74. Hinged Space: An enclosed room.

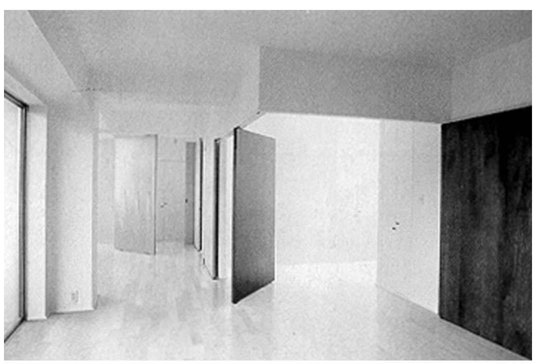

Figure 75. Hinged Space: An open room.

The ability for the patient to manipulate their surroundings to alter room configuration to satisfy human needs and behavioral patterns could resolve the lack of diversified space and promote healing. For example, in the design of the “Hinged Space Housing Project” by Stephen Holl, sliding, tilting and rotating panels that are hinged and pivoted are employed that allow inhabitants to adapt to a wide variety of individual and collective needs. These panels are used to invent and reconfigure living spaces, adapting to nighttime and daytime cycles, periodic needs or changes in the lives of the inhabitants. This type of interactive space can allow a multitude of spatial configurations. In the I.C.U. environment, hinged walls or glass panels can be implemented to open a room to a nursing corridor for increased visibility and enhanced medical care. Those same panels can be used to create acoustical or visual privacy for rest or solitude. They can also be used as a physical barrier between family zones and patient zones and allow for in-room family stay. The degree of configurability of the room and spatial diversity required can increase and adapt as the patient get healthier.

Mobility, Stimulation and Engaging the Environment

The human brain is an extremely complex neural network that forms at birth, grows and organizes itself during infancy and further expands and reorganizes as it processes and responds to a vast array of stimuli received through the external environment. Links have been made between the degeneration of neurons that compose the brain and inactivity or lack of mental exercise and stimulation. Patients in health care settings who tend to be severely ill and disoriented are typically mobility impaired, spend a lot of time in the prone position and are especially subject to a lack of mental stimulation. Often, the design of our health care environments do not enable patients to engage with their immediate interior environment as well as the outside environment. The lack of mental stimulation, coupled with the patient's inability to move, creates an environment that is conducive to feelings of confinement and stress and can therefore be considered unhealthful.

In *Archetypal Places*, Mayer Spivack drew parallels between the amount of confinement and the degree of illness in the institutional setting. He said, "the sicker one

Figure 76. Stimulation in an environment.

seems, the more one would be confined; the more one's confinement, the sicker one seems" (Spivack, pg. 45). He is specifically referring to the amount of freedom inpatients, particularly mental patients, had to move about their environment and partake in the opportunities to be active. The paradox is circular. People feel confined when they are disoriented and are unable to find their way in building. Confinement is also perceived when there is a lack of options or diversified settings that patients can experience, what Spivack refers to as "setting deprivation." Confinement may also come from the physical inability to move because medical protocol does not allow it, or a patient relies too much on cumbersome medical equipment or their sickness has rendered them immobile.

Stress can be brought on by a lack or overload of stimulation in the environment. Our minds process the amount, properties and qualities of the stimuli in the environment. Properties of stimulation can be degrees of intensity, variety, complexity and mystery. Too much or too little stimulation can yield an improperly balanced environment as

Figure 77. An acute care patient room with too little stimulation.

people tend to function optimally at more moderate levels. In the Journal of Environmental Psychology, there is evidence that links a lack of stimulation to boredom and, on the extreme end, sensory deprivation (Evan and McCoy, pg. 85). The photo in Figure 77 is an example of room that is devoid of stimulation with a lack of detail, decoration and contrast of materials or colors. There is also none of the accoutrements that are typically found in the home environment such as furniture, accessories, artwork and we can only assume that provisions are made for storage, personal effects and accommodations for family as can be seen in Figure 78.

Figure 78. An acute care patient room with moderate levels of stimulation.

Contrast to this, over stimulation such as in Figure 79, has been known to cause interruption and difficulty in focusing because there are too many objects, machines, noises, colors, textures, etc. that demand our attention and interfere with our cognitive processes. Often, intensive care environments are associated with over stimulation associated with an abundance of medical equipment and other technological devices located within the room. Also, loud noises, strong odors or bright colors all affect the

Figure 79. Over stimulating I.C.U. environment.

intensity and variety of a stimulus. Complexity and mystery refers to the degree of variety, diversity and the promise of further information in a setting. When intensity greatly varies from more moderate levels, an environment can become confusing and unanalyzable, which consequently results in a stressful situation.

Typically, medical settings and medical practices are not conducive to allowing or supporting stimulation or movement. However, the Planetree model of "patient-centered care" addresses the medical practices and operations that contributes to perceptions of confinement. This philosophy is "based on offering patients choices and individual control over most aspects of their care, which runs counter to the strict timetables and treatment protocols that enable hospitals to function efficiently" (Malkin, pg. 23). The object is to empower the patient to become actively engaged in the healing process, something that Norman Cousins discovered during his illness in the 1970s. The Planetree model of care however, focuses more on the interior operations than on architecture. There are some specific programmatic impli-

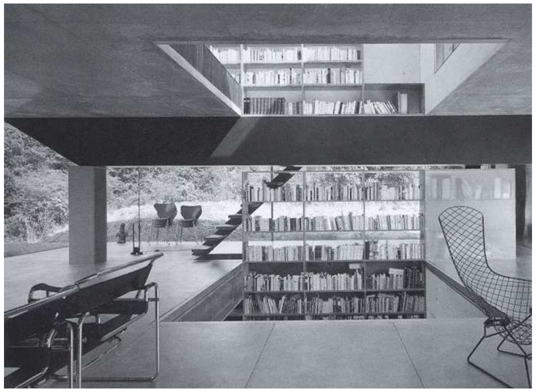

Figure 80. Bordeaux House: Floor without platform.

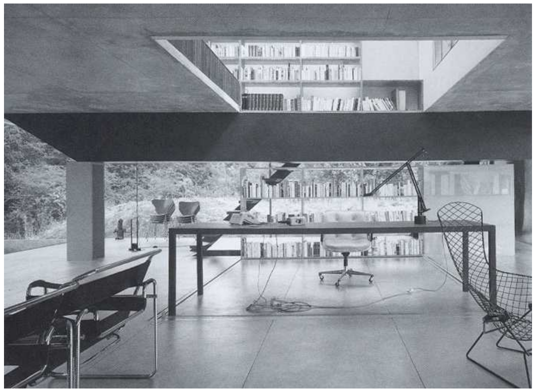

Figure 81. Bordeaux House: Floor with platform.

cations in that family, social, educational and gathering spaces are typically essential to this philosophy. The Planetree model of care does operationally what this thesis seeks to do architecturally and that is to engage and stimulate patients with the ultimate goal of helping to improve the healing process.

The ability for the patient to manipulate their surroundings and alter their position within the room or building could resolve confinement issues, be more engaging and promote stimulation. Technology could play a role in helping resolve this issue. For example, the "Bordeaux House" by Rem Koolhaas was designed to accommodate a family whose father is confined to a wheelchair following an auto accident. The house is composed of three levels that are connected by a ten-foot square vertically moving platform. The three levels, along with the enabling platform, serve different behavioral patterns; the lowest level allows for family and communal life, the middle serves as workplace and study and top level accommodates the most private and intimate living functions. The house, with the elevator room as the binding element, was

Figure 82. Patient room with mobile technology offers potential for mobility.

designed to liberate the father from the "prison-like" confines of the previous house. Along one wall of the elevator platform is a continuous surface of shelves for access to books that are a necessity for the publisher-resident. The design of the house enabled the family to function as well as increase mobility, control and empowerment and ultimately be liberating.

Technology, similar to what was employed in the Bordeaux House, could be utilized in the intensive care setting as well to create an environment that is more stimulating and engaging with the patient. The photo on the right depicts a patient room where the patient in the bed is hooked up to a medical gas boom. The medical gas boom can swing, rotate, telescope, raise and lower to accommodate a patient's position within the room. However this technology is rarely used to enable, for example, the patient in the photo to be nearer or facing the window instead of the interior portions of the building. The function of the boom is mainly for staff access behind the patient's head in the event of emergency. Also, if the boom moves then the patient bed, medical equipment and other furniture within the room need to be moved with the boom separately. The components should be designed to interface or engage together to move as a cohesive unit and be more user friendly.

Orientation and Spatial Comprehension

Medical settings should be arranged and organized to provide coherence. Coherence in a building enables users to make reasonable deductions about the identity, meaning and location of spaces within a building (Evans and McCoy, pg. 87). When buildings are disorganized and users cannot discern underlying form or detect a pattern of spaces, stress will result. This is not to say that buildings need a monotony of rhythm. People can get lost in monotony as well, as if a city was composed of nothing except city block after city block with every façade and dimension being the same. Instead, people need to be able to read and understand their environment, by having regular building shapes periodically broken up by distinctive elements with connections to the exterior environment.

Parallels are often made between cities and medical settings because of similarities in organization, structure, complexity and variety of components. In order for a city or medical setting to be understandable and easily navigable, it has to be properly structured and organized so inhabitants can read visual cues and landmarks to facilitate

Figure 83. Medieval City Plan.

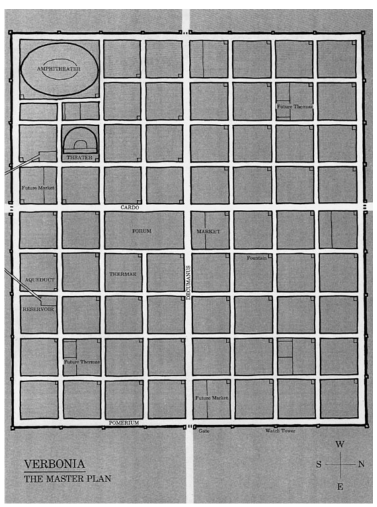

Figure 84. Roman City Grid Plan.

movement. The Medieval city shown in Figure 83, is an example of an environment that was designed with winding narrow alleys to intentionally cause confusion to the visitor or intruder, whereas the Roman city in Figure 84, was designed for clarity, predictability and regularity. The Roman city is the basis of many modern cities because the design facilitated organized movement of a mass quantity of people toward inward and outward destinations.

Older models of hospitals such as the pavilion hospital, although of tremendous size and scale, were generally regular in order, predictable in shape and clear with regard to the internal organization and spatial comprehension. There were also many way-finding cues such as courtyards or connections to landmarks that helped the visitor navigate the interior. As the hospital grew more complex and departmentalized, it eventually got more massive and bulkier as each of these departments was essentially interdependent and required physical connection. Separation of these departments by thousands of square feet of courtyards would have resulted in an inefficient and wide-

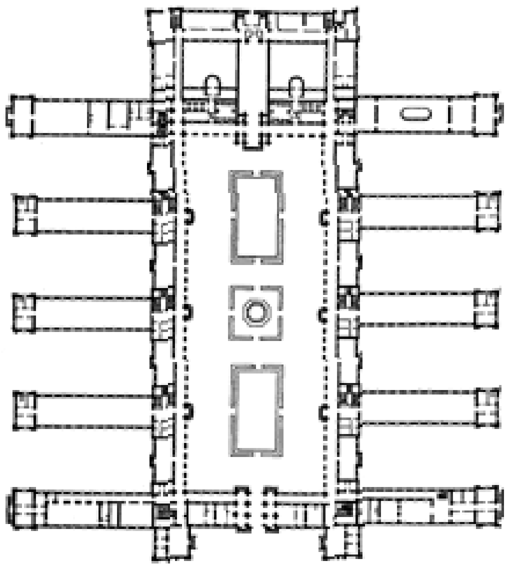

Figure 85. Pavilion Hospital Plan.

Figure 86. Typical hospital plan of today.

spread floor plan that increased walking, transportation and staff travel times. Without visual cues, the corridors in these facilities are typically nondescript and rather easy to disorient. The advent of technology in the hospital precipitated continuous change and these corridors systems became even more corrupt, winding and difficult to navigate. This also created a sense of confinement and thus a lack of control.

A healing environment should provide for comfort and control by implementing technology to enable an environment that is more comprehensible and better orienting. A major force that is contributing to the way hospitals will be structured and organized in the future is information technology. Technological devices, systems and networks are used to store, retrieve, distribute, present and communicate a vast quantity of information in a very short period of time. In older hospital models for example, a patient record had to be retrieved by administrative personnel from a large medical records storage room located within the hospital that is filled with shelves of files that looked the same and transported by foot to a clinician who needed to check for aller-

Figure 87. Hospital corridor that is difficult to read.

Figure 88. Hospital corridor with landmarks that is less difficult to read.

gies in a patient admitted to the emergency department. In many hospitals today, the clinician, while with the patient, can access a bedside computer, enter in basic patient information and retrieve an electronic medical record instantaneously. This record is stored with information on thousands of other patients on a mainframe database, not within the hospital, but possibly hundreds of miles away in another city. Similar to electronic medical records is PACS or picture archiving and communication system, which is a database for X-rays, mammography and other radiology images. Bar-coding and scanning technology is also used for point-of-care on nursing floors to ensure administration of proper medications as well as tracking of hospital supplies used for patient treatment. These technologies are replacing time and motion functional relationships with digital ones and are enabling greater decentralization of support services such as satellite pharmacies and off-site warehouses. No longer are mass quantities of materials stocked within the walls of the hospital.

Technologies can enable a facility to be more orienting, understandable and compre-

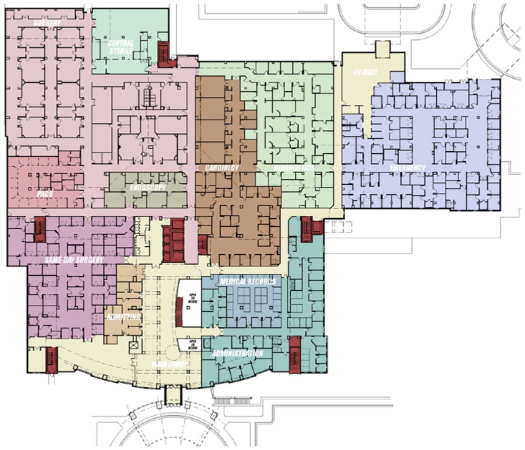

Figure 89. Centralized hospital plan.

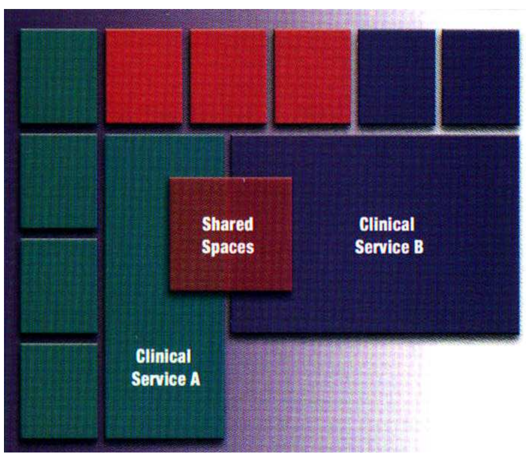

Figure 90. Decentralization Diagram.

hensible. With the example of information technology, the amount of space required for the storage of medical records can be reduced as the medical records storage area no longer needs to be central to the hospital, distance is no longer relevant and time has been compressed exponentially. Since technology has the capacity to reduce the size and complexity of hospitals, the result is consolidation that only includes essential services and increases the ability for better orientation and an understandable structure. More legible buildings can be designed by breaking up the thick, bulky modern hospital of today into smaller decentralized blocks. Decentralization means that the massive departments, such as surgery, radiology and emergency that once composed the typical hospital are being subdivided and separated to form the smaller hospital of tomorrow. There is no longer need for a central nurse station, central lab or respiratory therapy department. Registration or information gathering can be done remotely at the bedside or at home through the internet. Facilities would continue to become larger, more centralized, thicker and bulkier without these new abilities to communicate by way of computer, E-mail, cellular phones, or pagers and the ability to share information expediently, If we did not have a superior ability to communicate by way of computer, email, cellular phones, or pagers as well as have the ability to share information expediently, facilities would have continued to become larger, more centralized, thicker and bulkier. The critical time-motion relationship of physically-connected hospital models has been diminished by a virtual and computerized era. The consolidated and compacted design of the decentralized hospital affords the opportunity for a more clear and concise user experience from both a staff, patient and visitor perspective.

Conclusion

Technology, where employed in the tertiary care medical setting, reinforces the paradox when it is disabling and tempers it when it is enabling. Technology is disabling when it takes away patients' comfort and control by being disorienting, inflexible and confining. The result is an environment that causes much stress and impedes the healing process. Architecture is not completely responsible for this stress, nor can it completely reconcile the stress. The health care - technology paradox can only be adequately resolved if there is an integrative approach between the design of the medical setting, medical equipment and practices. Medical settings alone can only help compensate for the negative effects caused by technologically sophisticated medical equipment and medical practices.

In order to mitigate the negative effects caused by technology, architecture can play a tempering role in optimizing the comfort and control that patients need. This control can be provided over physical elements in the environment, or they can be a perceived control where the design of the hospital helps minimize stress by being easy to comprehend as well as engaging. To provide for comfort and control, architecture should be comprehensible and reassuring, engaging and stimulating, and providing flexibility to allow for change. Through this, a healthful and therapeutic environment can be attained. Generally we are comfortable with technology when it is enabling and understandable, and we are uncomfortable with it when it is disabling and unfamiliar. And, when given a choice, patients voluntarily seek those medical settings with the best medical practices and equipment because they are reassuring and result in the best health care outcomes. If these advanced medical technologies and practices are readily available, then people will seek those medical settings, including it's technology, that are most therapeutic and enabling.

DESIGN CRITERIA FOR EMPLOYING ENABLING TECHNOLOGY IN THE TERTIARY CARE SETTING

The tertiary medical care setting should employ enabling and therapeutic building technology as well as accommodate enabling and therapeutic medical practices and equipment so that the health care experience can be optimized. The following design criteria are focused on the design of tertiary care environments as they are the most complex and contains the most sophisticated medical practices and equipment. Although the intent of technology in the medical setting is to provide positive health outcomes, the result has been somewhat paradoxical. Instead of these technologies in the medical setting being stressful and disabling, they should be employed to be enabling and therapeutic. In order to be enabling, technologies should provide for comfort and control by promoting spatial comprehension, stimulation, setting diversification, and environmental optimization. At the same time, medical settings need to functionally accommodate medical equipment and practices to create a cohesive environment where the technologies are fully integrated.

Employ a Building Framework that Enables Order and Flexibility

Figure 91. An ambiguous intersection in a corridor.

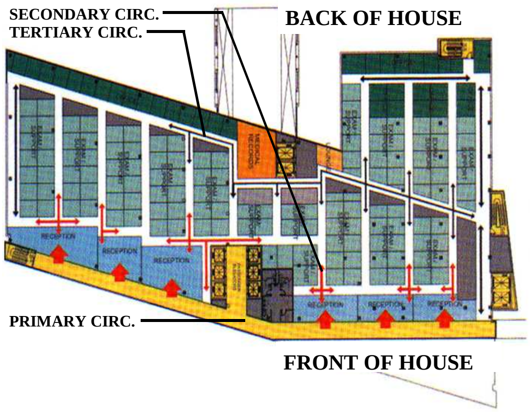

Figure 92. Clear and legible hierarchy of circulation.

Tertiary care settings should be designed with an orderly, regular and predictable framework that has simple, clear and direct paths yet still retains flexibility to accommodate the technological change and growth of medical equipment and medical practices. Decentralization enables hospitals to function in a more compact way to allow simplified buildings with shorter, more direct and clear paths. When building design neglects to be clear and orderly, it is more difficult to navigate through a building and find destinations. Furthermore, if buildings do not have a regular and predictable planning framework, then chaotic change can occur over the life of the building. The lack of a clear planning order typically results in floor plans with a many turns and changes in direction that one must take to reach their destination, ambiguous intersections, such as in Figure 91, and unnecessary jogs in corridors.

A commonly known geometric principle is the shortest distance between two points is a straight line. Although this occurs infrequently in most hospitals, the point is that a system of interconnecting and hierarchical pathways should be established to facili-

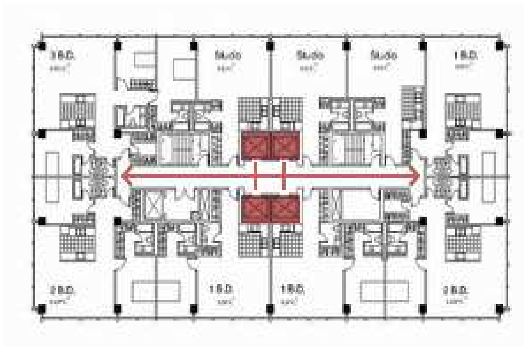

Figure 93. High-rise plan showing clear and direct paths from elevators.

tate clear and simple movement in the most direct way possible. As in Figure 92, there should be a clear and legible hierarchy of circulation from primary pathways to secondary, tertiary and finally private back-of-the-house service pathways for staff and gowned inpatients. Clarity also results in time efficiency and, in a hospital, allows materials, pharmaceuticals, personnel, patients, etc, to be transported in the most direct and fastidious way.

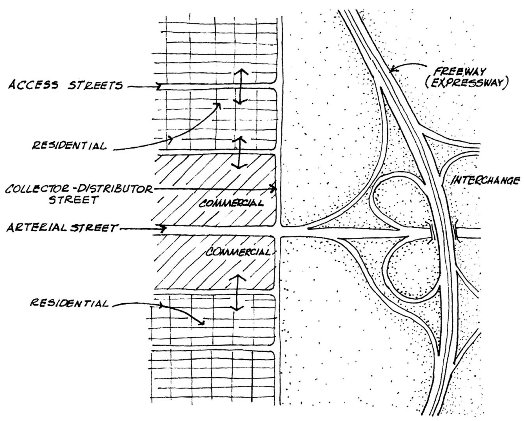

Figure 94. Diagram of hierarchy of U.S. highway system.

High-rises and skyscrapers are equipped with a system of elevators to quickly move a large number of people throughout the building. In Figure 93, most of the movement is upward through a central core and because of the compact floor plate, circulation is fairly short and direct once the desired floor is reached. The transportation and highway system in the United States in Figure 94 is another example of a network of pathways that connect us from major destination to major destination. A fallacy of the highway system that should be avoided in buildings is that they more often than not tend to be monotonous and without stimulation. Anything notable on open stretches

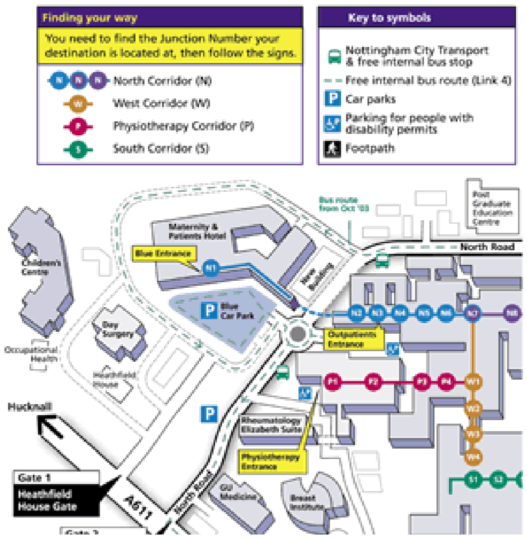

Figure 95. Confusing Hospital Signage.

Figure 96. Tree of Life: Orienting sculpture in MD Anderson Cancer Center.

of highways is absent, making the driver reliant on signage and billboards. In buildings, the extensive use of signage is generally discouraged, as these too can be difficult to follow (Figure 95).

More effective pathways have landmarks or anomalies that the visitor can easily remember such as exterior cues, courtyards, sculptures or other works of art, light wells and vertical spaces. The position of these landmarks is more effective at decision points or transition areas along a path. These can also be used as a major orienting device throughout a building, connecting a person's present location to that of where they have been. For example, the M.D. Anderson Cancer Center Tree of Life sculpture in Figure 96 is placed along a primary route, in a large open vertical space and is used a wayfinding device. The courtyard and light well used in London Bridge Hospital in Figure 97 serves to let in natural light but also serves to orient people as they pass through or adjacent to such an outstanding space.

Figure 97. Atrium in London Bridge Hospital.

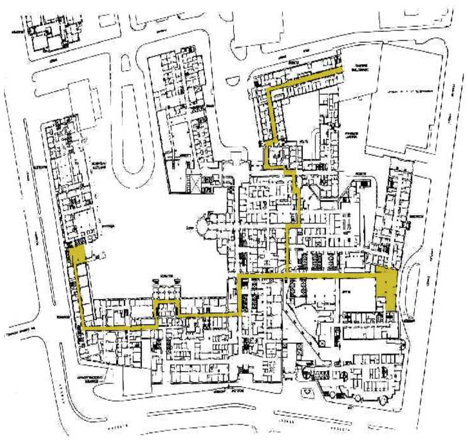

Figure 98. The hospital labyrinth—the result of chaotic change.

Along with a system of clear paths, there should be a framework that maintains integrity and clarity and allows change to occur without sacrificing spatial orientation and comprehension. What happens in medical facilities over time, as can be seen in Figure 98, is the main paths often get altered, changed and convoluted as adjacent spaces or departments grow as the result of technology. Technology is often what drives the design of the floor plate and has the propensity to result in chaotic change over time.

A building with a regular, predictable and orderly framework is more likely to maintain the organizational integrity amongst spaces, corridors, departments and thus the entire facility over time and throughout growth and change. This can be done by creating channels for growth that stem from main arteries or fixed volumes, such as an atrium, and grow into a flexible, but predictable structural framework. This is analogous to urban design, where the infrastructure, streets, bridges, etc. are stable elements and what changes is the internal composure of the blocks in between. The structural framework for a building should be as open as possible to accommodate in-

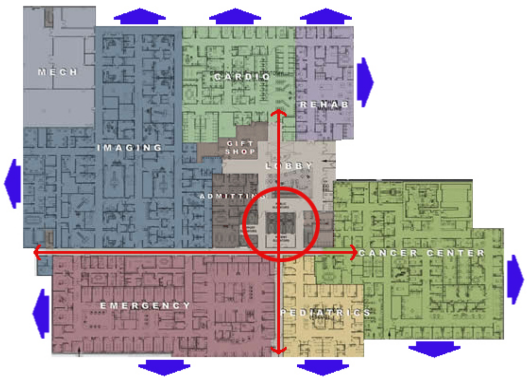

Figure 99. A predictable and orderly framework.

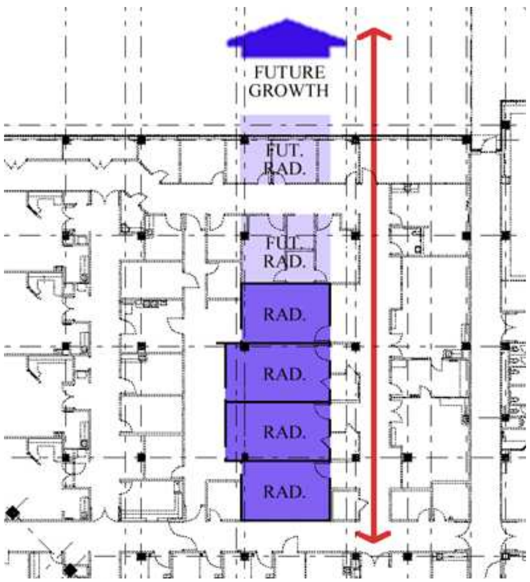

Figure 100. Growth into soft space.

terior alteration and meet the need for technologies that require vast space and demanding infrastructure. For example in Figure 100, a radiology suite may have been designed with storage spaces, shelled areas or potentially offices or conference rooms along an exterior wall. It is relatively easy to rework a cluster of these “soft” spaces for new technology. A flexible structure will also allow change to occur over more condensed periods of time, bringing the therapeutic equipment and practices online for patients in a quicker timeframe.

Employ Information Systems to Allow Smaller Building Footprints

Information technology has redefined the way people communicate within the hospital as computers, cell phones, wireless networks, global positioning and scanning technology has increased the amount of data transferred between locations and has enabled it to be done from remote areas. Tertiary care settings should be designed to utilize the advantages associated with information technology and the decentralized hospital to enable more compact and thinner building floor plates instead of widespread, massive buildings. Because most information now travels digitally over computerized networks, larger centralized departments, such as Respiratory Therapy, Pharmacy, Laboratory and Diagnostics can be divided up and redistributed into smaller blocks to better serve medical specialties such as Neurology, Orthopedics, Cardiology or Obstetrics. Decentralization has also allowed support services provided with the hospital to be reduced by locating them offsite to be shared with other hospitals. By reducing the amount of services, relying on remote communication methods and spreading the remaining services throughout the building, the organization and structure of the hospital can change dramatically. The end result will be hos-

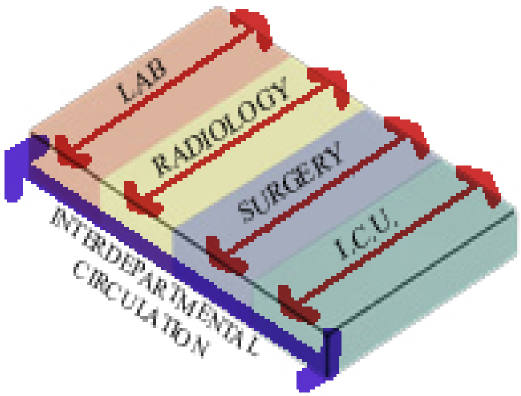

Figure 101. Typical 20th Century Centralized Hospital Typology.

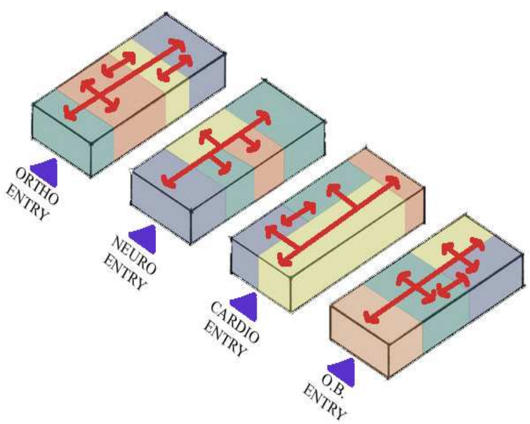

Figure 102. Horizontally Arranged Decentralized Hospital Typology.

pitals that can be spread out through the community, or multiple hospital buildings located on a single campus each with a separate entry. Or, multiple specialty services could be in one building vertically stratified into distinct centers of excellence.

As depicted in Figure 101, the twentieth century typology of the hospital found most departments adjacent to each other because, in general, information was transferred by way of walking. Information included charts, patient medical records, X-ray films, registration, financial records, lab results or medication. Surgery typically required adjacencies to radiology, internal medicine, anesthesiology and the lab. Now, surgical suites can be designed in certain circumstances to incorporate all of those services into one department with increased efficiency. The new organization, as depicted in Figures 102 and 103, shows that hospital services no longer have to be centralized departments. For example, the green in the diagram could be an I.C.U., whether it is a medical, surgical or coronary care I.C.U. The red could be the lab and the yellow can be radiology, or case management or biomedical services for that matter. Larger departments can now be divided up into smaller and more coherent blocks as illustrated in Figure 104. Also, they are not necessarily contiguous departments any more because they are no longer a centralized whole. Collectively though, departments that are spread throughout the hospital may not necessarily be physically smaller as many spaces will be replicated from specialty to specialty. Departmental decentralization essentially allows a hospital within a hospital and centers of excellence. No longer do we need centralized areas where the medical expertise is functionally collocated within a single department.

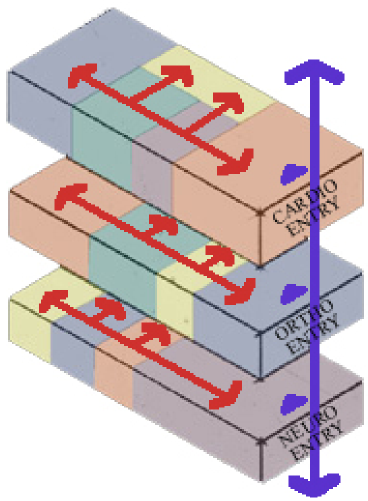

Figure 103. Vertically Arranged Decentralized Hospital Typology.

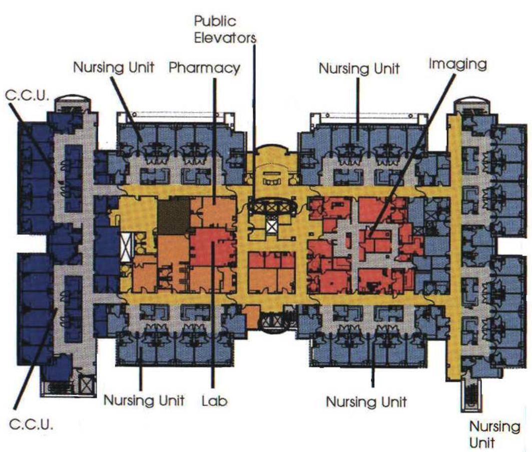

Figure 104. Specialty service floor with decentralized support departments.

The hospitals within a hospital concept can allow more compact buildings to be set up. Specialty service line "hospitals within hospitals" can be scattered throughout a geographic region or, as in Figure 105, they can allow services to be located on the same site but in different buildings or services can be stratified vertically and stacked. These self-contained operational units can allow simplified massing that is easy to comprehend from the outside and inside. It can also allow better building organiza-

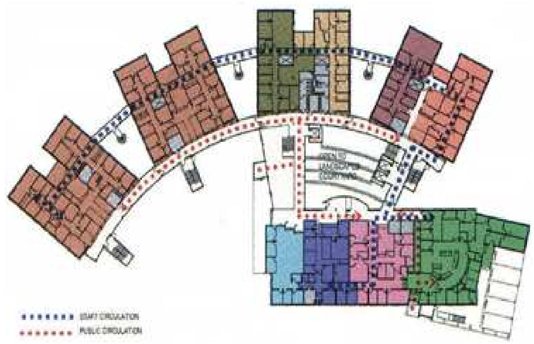

Figure 105. Specialty services located in different buildings on same site.

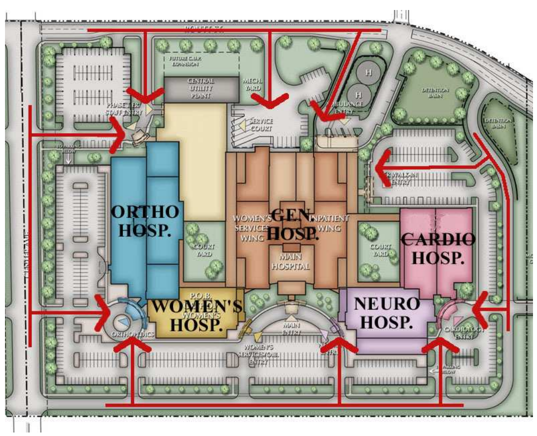

Figure 106. Clear wayfinding for hospitals within a hospital.

tion as all services necessary for a specific hospital population may be located within a condensed area. Patients and visitors for a given diagnosis or disease specialty have no need to go anywhere else within the building. Wayfinding patterns, such as those in Figure 106, can be more clear and simplified, and travel times can be decreased for patients, visitors, staff as well as materials. This will also allow services to be brought to the patient in a quicker and more efficient manner. Smaller and thinner buildings also increases the amount of exterior wall in proportion to the area of the building footprint allowing more exposure to daylight, airflow and connections to nature on the exterior. The shorter travel paths can provide for increased orientation and spatial comprehension, which in turn could reduce stress.

High-rises and skyscrapers are examples of buildings that are stratified vertically. These buildings are generally found in urban areas because land values tend to be expensive and developers maximize rent by building high and having more tenants to offset the development costs. However, the concept can be akin to the hospital be-

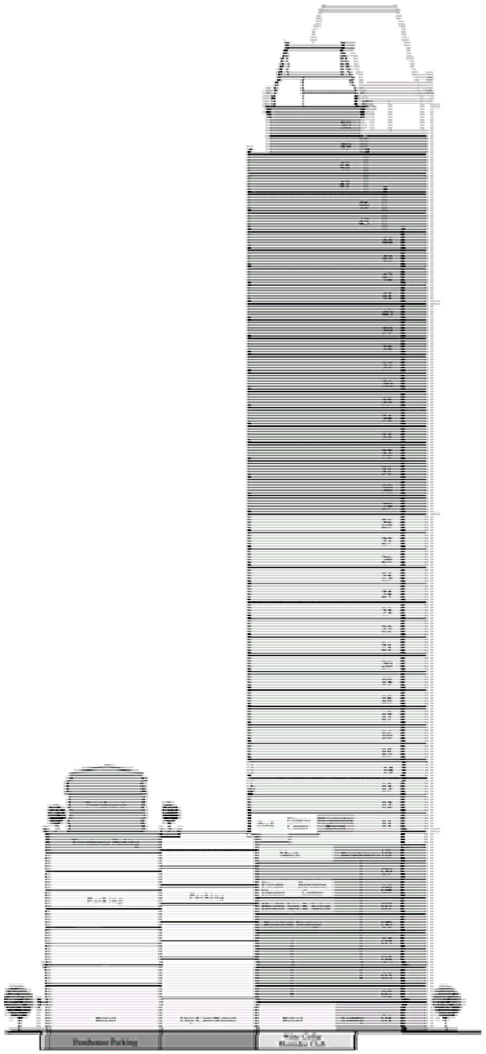

Figure 107. Skyscraper: stratified vertically.

cause in high-rises, there are typically different business offices on each floor which include their own administrative department, sales and marketing, research and development, accounting, regulatory and compliance as well as information technology department. The key difference with a high-rise building between business offices and hospitals is expandability. The hospital floor plate must be able to flex or accrue to accommodate more dramatic change than could be expected for an office building. But as far as providing service lines to the customer, each business within a high-rise can offer a different product, much like what could take place in a decentralized hospital. Other benefits to a vertically stratified building are expansive facades with vast areas of glass as well as a simplified circulation system. This façade of glass, views to the exterior and simplified wayfinding system make it more likely that the occupant will be oriented while circulating throughout the building. This concept can allow architects to overcome some of the modern shortcomings of twentieth century hospital design that were a result of technology.

Employ Mechanisms in Patient Rooms that Empower Patient with Control

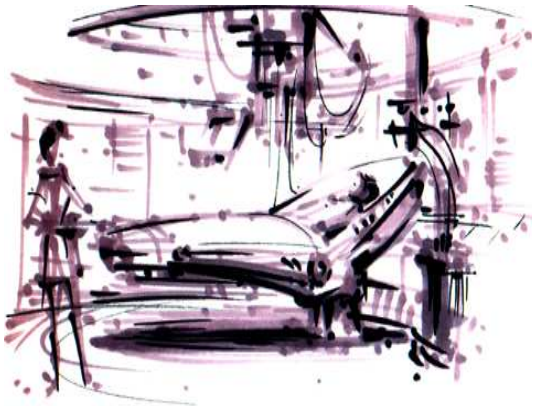

Figure 108. Future patient room with mechanisms that allow control.

Tertiary care settings should be designed to utilize simple mechanisms that enable control over devices that can alter and improve physical aspects of the environment in which the patient spends the most time. Typically, patients will spend a majority of their hospital stay within the patient room. This should be the patient's home base throughout their stay, a stable place they can call their own, personalize and grow familiar with especially during longer stays. It is important that these rooms are for one person as it is hard to personalize and control an environment, allow for maximum privacy and identify with a setting when it is shared with a stranger. The room should also be universal, meaning that the room should be sized and equipped to enable the patient to receive all of the care necessary from beginning to end of their stay within that one room.

As care of the patient typically begins today after a procedure such as surgery, the patient is frequently in their most critical state. They require much attention from staff, continuous monitoring, around the clock observation and constant testing. This care takes place in a critical care setting in a hospital without universal rooms and as the health of the patient progressed, they are moved to a step-down unit and then yet again to an acute care patient room.

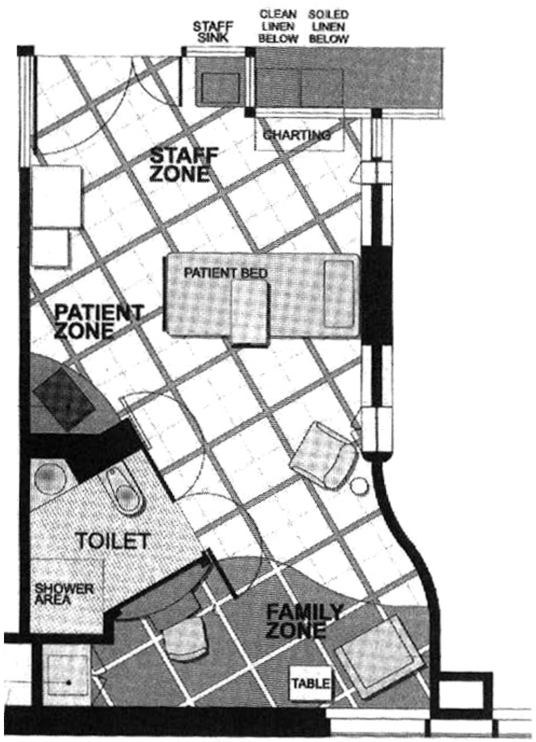

Figure 109. Universal patient room.

In a universal patient room concept such as in Figure 109, the patient would get healthier while remaining in the same room. Orientation with their surroundings is more easily maintained and familiarity with staff is more constant. Moving from place to place during stay could ruin the identity that a patient has with the environment. Operationally, staff will need to be cross-trained, so that they are capable of caring from a patient in their most critical to most stable condition. Decentralization of the hospital makes this possible by segregating the patient population into more homogenous groups where all patients have a similar illness. Cardiac care settings are the most applicable because illnesses are usually more severe, multiple levels of the severity of care are required and hospital stays are typically longer. Patients in these environments typically go from having control over their lives, to having very

Figure 110. Paimio Sanatorium.

little control during severe illness and then trying to regain control to live normal lives.

The early twentieth century pavilion hospitals, epitomized in Alvar Aalto's Paimio Sanatorium (Figure 110), were designed to be places for healing. The design of these buildings maximized sunlight, airflow and views to the exterior, minimized noise and allowed for privacy. The Sanatorium was designed with sensitivity toward sight, sound, smell, warmth and cold as the conditions of the environment were critical for patients who spent months recovering while in a supine position. Although pavilion hospitals achieved this therapeutic value through fairly low-tech methods, the buildings and the high technology of today can once again offer more control of these physical aspects. Devices should allow patients to control sunlight, heat, air movement, sounds and white noise, smells from the exterior and views to nature. This can be allowed by control over the building envelope and fenestration system through devices that include shading mechanisms, window openings, louvers, thermostats, sup-

Figure 111. Intelligent Workplace.

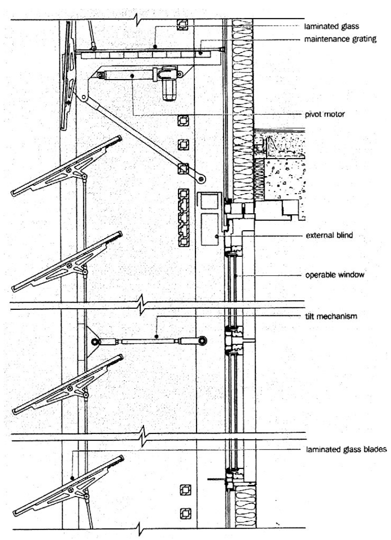

Figure 112. Sunshade Detail at Debis Tower.

plemented by artificial lighting and mechanical air. The Intelligent Workplace at Carnegie Mellon University (Figure 111) sets up microenvironments by providing users with a desktop "environmental control module" that allows control of sunlight, airflow, temperature and noise level. Sunlight is controlled by mechanical shades at windows, louvers and operable windows control airflow, re-locatable air diffusers and ventilators regulate temperature and a low volume electronic sound screen can mask noise (Schmertz, pg. 153). Renzo Piano implemented a system similar to this in the Debis Tower in Berlin (Figure 112). Done over a much wider scale (the building is approximately one million square feet), the façade allows for user comfort and control through an elaborate double-curtain wall system that provides operable windows, tilting mechanical shades and external electric blinds to modulate climatic conditions (Russell, pg. 128). This type of façade is becoming popular in northern Europe because of energy conservation and especially so in Germany because of laws that limit depth of floor plates and distance workers can be from windows.

Figure 113. Legacy Good Samaritan: Overhead boom allows adjustability.

Privacy, or the lack of, in a hospital is a psychological concern. A sick and hospitalized patient has to accept the given environment whereas a healthy person can leave a room or change it to suit their needs. Unwanted intrusions into a room are found to produce an elevated amount of anxiety (Malkin, pg. 17). The control of a patient's position within the room can regulate privacy, both visual and acoustical, as well as alter spatial configuration to allow for care to take place, provide room for visitors as well as adjust to the need for solitude. Headwalls in hospitals should have some flexibility to adjust position within the room. In the Intelligent Workplace, users can change position throughout the building, when uncomfortable for any reason, by unplugging and plugging in mobile workstations. This type of flexibility may not be appropriate for hospitals. The Legacy Good Samaritan critical care room (Figure 113) in Portland, Oregon provides a boom, with flexible, rotating and telescoping components that are suspended from the ceiling that allows equipment and medical gasses to move around with the patient. This was not necessarily done to provide a patient with optional setting configurations and increased privacy. It was done more so to provide care-giving staff with more control and flexibility (Willette, pg. 308-311). While at a higher acuity the patient can be positioned toward the interior for staff observation but could also be re-positioned for views out of windows while at a lower acuity.

Being sick usually means losing control, and re-gaining control usually makes people feel better and is perceived by most as an indicator of recovering from injury or illness. In an article in Nursing Management in March of 2000, research has shown that the ability to control the environment has a healing effect (Murphy, pg. 38). When people have some control over events such as activities, privacy and noise, their environment becomes more predictable, which has a stronger positive effect on stress reduction (MacArthur).

Conclusion

These criteria are created to assist in the design of the technologically sophisticated tertiary care medical facilities that contain the most advanced medical equipment and complicated medical procedures. Enabling technologies should be employed in these settings to provide comfort and control in order to have a positive health outcome. This can be achieved by providing patients control of mechanisms to optimize the environment, control privacy and provide stimulation. Also, providing smaller building footprints allows better orientation, spatial comprehension and clearer wayfinding patterns. Finally, employing a building framework that establishes order while also allowing for flexibility will create a cohesive environment that functionally accommodates medical equipment and medical practices yet is therapeutic and healing.

TEST CASE

The purpose of this thesis is to define the role of architecture in addressing the health care - technology paradox. Technology in the tertiary medical center yields both positive and negative health outcomes because although it has statistically proven to be beneficial, in the short term it creates adverse health effects. It has been proposed in this thesis that architecture is not completely responsible for the paradox, nor can architecture alone resolve all of the negative effects caused by technology. But, architecture has the potential to temper effects of the paradox by generally providing a therapeutic environment, effectively accommodating medical practices and equipment, providing flexibility to accommodate changes in medical practices and equipment, and promoting comfort and control. Since the health care – technology paradox is most prevalent in critical care settings, this thesis proposes a Heart Hospital for the Laguna Honda section of San Francisco, California. This facility proposal will involve an integration of enabling technology that combines sophisticated medical equipment and advanced medical practices with the most complex medical settings to help provide comfort and control to the one of the most ill population of patients.

The Heart Hospital

Medical centers that deal with critical illnesses are the most significant settings for exploring the architecture of enabling and therapeutic technology, and hence the paradox, because they demand and deliver the most advanced medical care for life-saving efforts on the sickest patients who have longer hospital stays yet are still aware of their surroundings. A heart hospital is a good example of a critical care facility because patients who need cardiac care services typically have poor health and suffer from life-threatening illnesses. In 2004, and for a number of years prior, the leading cause of death were from heart related diseases (Mokdad, et.al., pg. 1238). People who have cardiac related problems usually feel well a few days prior to a sudden event that forces them into the hospital for treatment, whether it is a heart attack, shortness of breath or pains in the upper body. These patients go from normal lives, in total control, to having to rely on sustained medical intervention in order to stay alive and feeling little or no control. Contrast this patient population to those who elect to undergo surgery, such as orthopedic patients or other surgical patients who have advanced notice of impending medical treatment. Cardiac patients are often caught by surprise and can be amongst the most vulnerable mentally and emotionally.

Because of the population, the nature of the illnesses and the type of interventions necessary for repair and treatment, heart hospitals are among the most technologically sophisticated with respect to medical equipment and medical practices. Heart hospitals are acute care settings in that they have a wide range of patients who are at different stages of recovery and who are receiving or have received comprehensive care. These hospitals need to be equipped and prepared to deal with emergencies and trauma, highly invasive and minimally invasive surgeries, and interventional and non-interventional methods of diagnostics as well as recovery units where patients are coming off of anesthesia. Patients can be in critical care units, telemetry units, where monitoring is continuous, or regular acute care units where they are nearing discharge. There is a significant rehabilitation component for these patients where they need to gain strength and relearn how to function normally. This cross section of people is generally in danger of loss of life.

Other settings that would be applicable to this thesis are academic medical centers, cancer centers, emergency centers or even comprehensive acute care hospitals that offer emergency, surgery, recovery and critical care services. Some of the larger institutions, academic institutions in particular, are generally on the cutting edge of new techniques and the latest experimental technologies. Cancer patients usually have to go through some of the most daunting medical procedures and treatments, whether they are surgeries, linear accelerator technology or gamma knife treatments. Emergency centers always need to expect the unexpected, whether there are shooting victims, motor vehicle accidents, falls, or other type trauma. These patients are usually the least able to cope with the stress of the situation. A heart hospital was selected as it allowed the greatest architectural focus on the thesis topic.

Site Selection Criteria

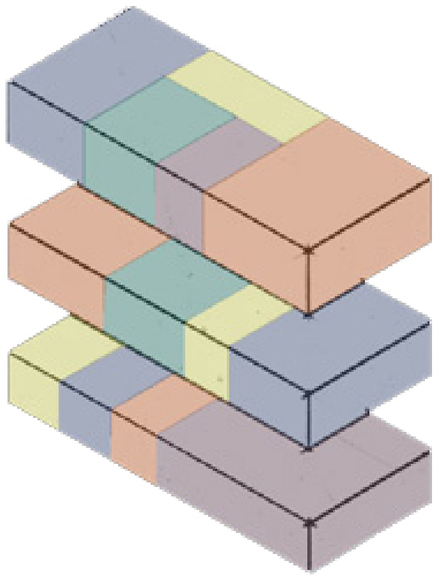

Figure 114. Vertically Decentralized Hospital.

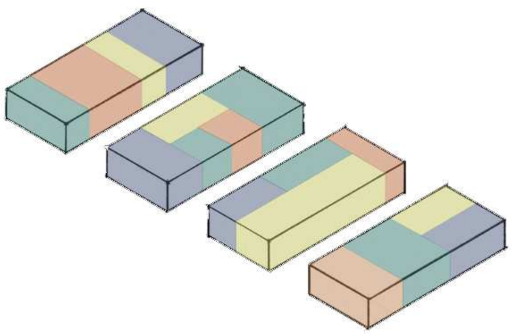

Figure 115. Horizontally Decentralized Hospital.

The relationship of the tertiary or critical care facility to the surrounding context should also be taken into consideration. A major reason for selection of a site is typically based on demographics and the clinical need for a service, however, given multiple potential locations within a certain service area, there are additional criteria that were used to evaluate specific site viability for this thesis. The site will also influence the general arrangement and form in which the building takes. For example, a decentralized hospital, as depicted in Figures 114 and 115, can take a vertical or horizontal form. A site with height restrictions could mean a horizontal arrangement while a smaller urban site may dictate a vertical solution.

In general, heart hospitals should be close to high-speed roads, either freeways or major arteries connected to freeways with a lot of visibility. The type of population that will need this care could be delivered in an emergency and will have a limited amount of time before medical staff can stabilize them. Access to sophisticated diagnostic and treatment technologies will be critical, so once to the site, the ability to expedite patients to treatment areas will be necessary. Multiple access points will be essential to separate traffic flow for critical and not so critical patients. Also, it was discussed earlier that it is important for decentralized hospitals to be part of a network or have transfer agreements with other facilities in the area. This will allow patients to obtain the best and most appropriate medical care, including the equipment, practices and environment that serve that population.

It is not particularly challenging to develop sites that are large, flat and open. Although, these sites would be adequate, the potential vertical arrangement for the decentralized hospital will allow development on small parcels, with obstructions or awkward geometry or difficult sloping terrains. A site with rather negative attributes for other hospitals can be used in a positive manner for this type of hospital. A challenging site also enables the study of various building technologies to overcome site handicaps, such as foundation and structural systems, conveying systems or elevators. After development of the initial building on a small site, future design will rely on these technologies to allow a flexible building, since horizontal expansions will be less feasible. Smaller sites will force the use of buildings with a smaller footprint.

Once the site is selected, the next important criteria is building placement on a site, or orientation. One of the most important factors for healing patients is the therapeutic potential of a site. For example, it would not be beneficial for a patient unit to be built on a tight site only to have the rooms in that unit face another building across a tight alley or city road. This orientation offers no healing value to the inhabitants. Now, if those patient rooms faced a busy city street, with markets, stores and activity there could be therapeutic value to the amount of stimulation provided by that setting, so long as the stimulation wasn't too excessive, loud or disturbing. But, studies have shown that views to serene nature scenes have had a positive effect and the activity in these settings is more constant and controllable in contrast to the busy city street.

As with most hospitals, demographics, visibility and access will be primary drivers for selection of a location. But in contrast to most hospitals, the decentralized vertical hospital will allow development of smaller more challenging sites, increasing the pool of potential sites. Hospitals are generally known for occupying massive areas, sometimes fifty to one hundred acres of pristine land. This land might otherwise have therapeutic value to an entire community and be preserved as open space or a city park. Even if located in land of this size and nature, a vertical and compact hospital footprint would allow more open therapeutic space for use of both patients and other inhabitants.

Site Context

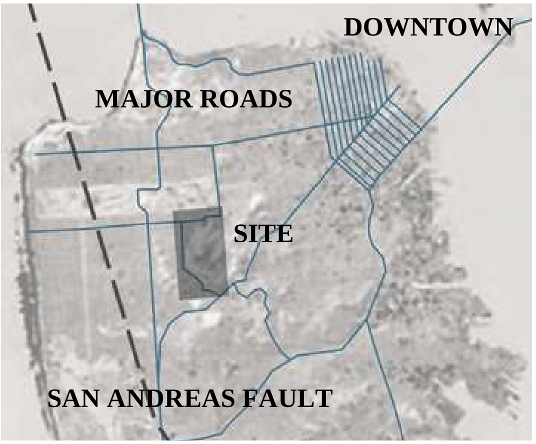

Figure 116. San Francisco Access Analysis.

Figure 117. Site Adjacency Analysis.

The selected site was an available six-acre parcel of land conveniently located close to the geographical center of San Francisco, removed from the central downtown business district and about one mile east of the San Andreas Fault line. There are several major arterial roads that provide easy accessibility. Interstate 280 is to the south, US-1 to the west and Laguna Honda Boulevard, which runs adjacent to the site that connects these roads. Laguna Honda Boulevard also connects two major medical centers, Laguna Honda Rehabilitation Hospital to the south and the University of California – San Francisco Medical Center, a major academic institution to the north. The site is located approximately halfway between these two hospitals. The site also happens to be at the southwest base of Mount Sutro, which is an easily identifiable mountain in the city of San Francisco.

About one-half of the site is occupied by Laguna Honda, which is essentially a retention basin along the south and west sides of the site. The other half of the site is steeply sloped and sparsely planted along the water edge. Just west of the site, across

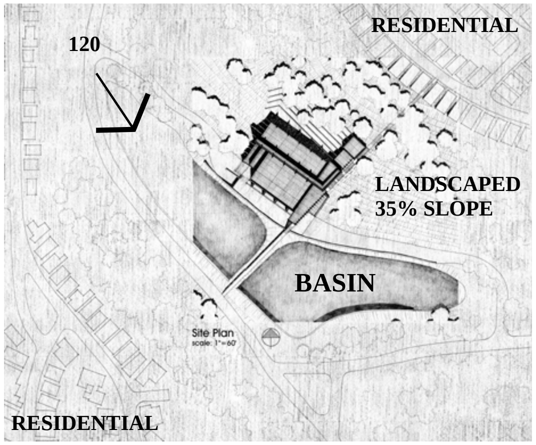

Figure 118. Hospital Site Plan.

Figure 119. Photo of Laguna Honda Forest.

Laguna Honda Boulevard used to be Laguna Honda Forest, which was at one time lushly planted and has since been demolished. The demolition occurred after the Loma Prieta earthquake in 1989 when the houses on top of this steep slope buckled and collapsed to the bottom of hill and onto Laguna Honda Boulevard. No funds have been allocated to have it replanted and will remain rather desolate and barren indefinitely. The site is marked with trails for walking which connect two neighborhoods in the northeast and southwest. Seismically, the silty and sandy soil conditions in this area are a concern for design and construction, as well as the proximal location to the San Andreas Fault line. Design on this site will require a combination of deep foundations, shear walls, cross bracing, base isolators and other types of shock absorbing structural provisions that can potentially influence hospital framework, layout and aesthetic.

The benefit to the site is the therapeutic potential of the landscape to the north and northeast. Despite rising from a rather barren and unremarkable retention basin, the land high on the northeastern slope can be quite bucolic. The most difficult handicap however is the slope of thirty-five percent which makes the site difficult to manage, design around and provide access to the building. The key point to building on such a site is to do it without destroying the qualities that make it therapeutic and therefore appropriate for critically ill patients. With the older, more sprawling model of the hospitals this would be challenging, but the potential for a vertical hospital would make this site appropriate.

Figure 120. Panoramic Photo of Site.

Program Description

The heart hospital will be a comprehensive and acute care facility that houses the most intensive medical services and contains some of the most sophisticated medical equipment. It will provide inpatient and outpatient medical services such as surgery and recovery, interventional diagnostic radiology and interventional therapies, emergency and trauma services as well as nursing units and critical care medicine. There are also the central support functions of the hospital such as laboratories, respiratory therapy, biomedical services, central sterilization and materials handling and processing. These settings are most applicable to the activation of the health care – technology paradox. However, these should not be the only criteria in defining the program. A facility that focuses only on the intense treatments associated with this type of care would not serve the emotional and psychological needs of the occupants.

If only intense clinical services were provided for, then this type of program would deprive patients who are staying for an extended period of time of different settings that are needed for stimulation and diversity. There is also need for patients to socialize with other hospital patients, as part of support groups, as well as family members and the administration of the hospital. There is also need to be educated by having resources such as medical libraries and clinics for the patients as well as their families. Patients will have to begin physical and occupational rehabilitation at the hospital to relearn their basic life skills. There should be settings where patients can be active, whether it is on the nursing unit or in other more congregative areas. Exterior spaces may be used for this as well. Nutrition is of primary importance as is the pharmacy and the need for drug therapies.

Older models of hospital-based care viewed the patient as a sickness or disease and not an individual that had physical, emotional and psychological needs. The approach was merely mechanical in that if the medical practitioners could fix the ailment in the body then the patient would be fine. What was not realized was that the treatments, clinical care and the supportive medical equipment were crippling patients by not allowing them control over their own medical situation. Diversification of the program components can form the building blocks for a therapeutic medical setting. Diversification with respect to the program of a heart hospital means there should be more to patient care than just interventional medicine, emergency, surgical and inpatient operations. There should be preventative medicine such as primary clinics for those patients that are predisposed to cardiovascular illness who need encouragement to be proactive in their own health care. There should also be an education component, or medical library, that provides areas where families and patients can learn about illnesses and procedures. Like education, an important part of a heart hospital is the nutritional care and rehabilitative medicine that can help patients sustain a healthy lifestyle.

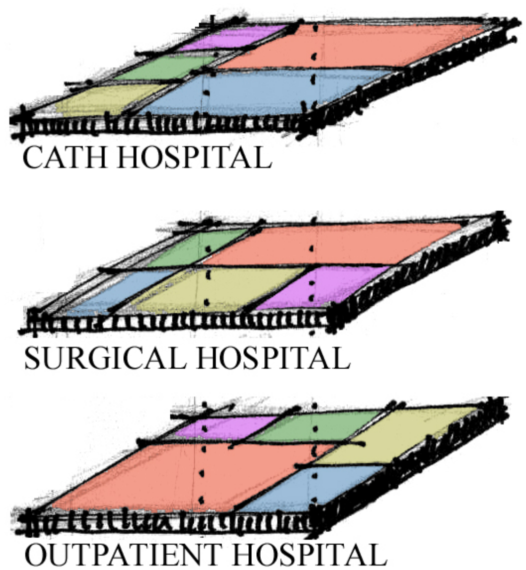

Figure 121. Programmatic Stacking Diagram (colors represent decentralized services provided within each floor. Example: yellow could be respiratory therapy which is split up and located in each hospital instead of located all within a single floor as in a centralized department).

Program Summary

Area Designation	Total NSF	Conversion Factor	Total GSF
Public Services			
Main Entrance	2,855	1.25	3,569
Kitchen / Café	2,950	1.25	3,688
Education Services	4,000	1.25	5,000
Family Services	4,660	1.35	6,291
Business & Administration	2,990	1.30	3,887
Medical Records	1,430	1.25	1,788
Public Services Subtotal			24,223
Diagnostic and Technology Services			
Outpatient Services / Pre-Admit Testing	2,250	1.50	3,375
Congestive Heart Failure Clinic	1,330	1.45	1,929
Pharmacy	870	1.50	1,305
Non-Interventional Radiology	5,785	1.50	8,678
Outpatient Services Subtotal			15,287
Interventional Radiology	5,510	1.60	8,816
Interventional Radiology Staff Support	1,980	1.50	2,970
Interventional Radiology Subtotal			11,786

Area Designation	Total NSF	Conversion Factor	Total GSF
Surgery	5,640	1.60	9,024
Surgery Staff Support	1,980	1.50	2,970
Surgery Subtotal			11,994
Emergency	2,420	1.50	3,630
Laboratory / Genetics	870	1.50	1,305
Respiratory Therapy	600	1.40	840
Subtotal			5,775
Inpatient Services			
Inpatient Area (60 rooms)	30,120	1.50	45,180
Inpatient Services Subtotal			45,180
Building Services			
Building Services and Engineering	6,330	1.15	7,280
Central Sterilization	4,500	1.40	6,300
Building Services Subtotal			13,580

Area Designation	Total NSF	Conversion Factor	Total GSF
Total Departmental Gross Square Footage			127,825
Building Grossing Factor			120%
Total Building Square Footage			153,390
Exterior Space			±10,000
Parking (96,394 / 2,400 = 41 & 31,431 / 300 = 105)			146

Detailed Space List

Space / Function	Number of Rooms	Square Feet Per Room	Required Net S.F.
Main Entrance			
Entrance	1,000	1	1,000
Reception / Concierge	200	1	180
Admitting Work Area	150	1	150
Main Waiting (35 seats)	525	1	525
Toilet, Public	275	2	500
Telephone Alcove	40	1	40
Wheelchair Storage	60	1	60
Housekeeping Closet	100	1	100
Gift Shop	300	1	300
Subtotal			2,855
Kitchen / Café			
Kitchen / Prep	1,500	1	1,500
Service Area	200	1	200
Serving Line	250	1	250
Café Seating Area (Public-50 seats)	1,000	1	1,000
Subtotal			2,950

Space / Function	Number of Rooms	Square Feet Per Room	Required Net S.F.
Education Services			
Reception / Check-out	300	1	300
Large Classroom	800	1	800
Storage, AV	140	1	140
Conference	200	2	400
Resource Room / Medical Library	1,800	1	1,800
Audio / Visual Room	120	2	240
Reading Room / Cubicles	80	4	320
Subtotal			4,000
Outpatient Services / Pre-Admit Testing			
Pre-Admit Consultation	100	2	200
Toilet	55	2	110
Sub-Waiting Area (10 seats)	150	1	150
Changing Room	50	3	150
Echo/EKG Exam Room	120	2	240
Ultrasound/Doppler	140	1	140
Treadmill Room	140	2	280
Staff Facilities	600	1	600
Staff Toilet & Shower	140	1	140
Conference Room	240	1	240
Subtotal			2,250

Space / Function	Number of Rooms	Square Feet Per Room	Required Net S.F.
Congestive Heart Failure Clinic			
Exam Room	120	4	480
Nurse Work-area	350	1	350
Conference / Classroom / Kitchen	500	1	500
Subtotal			1,330
Pharmacy			
Pharmacy	350	1	350
Pharmacy Sales	100	1	100
Hood Room	160	1	160
Pharmacy Storage	140	1	140
Office	120	1	120
Subtotal			870

Space / Function	Number of Rooms	Square Feet Per Room	Required Net S.F.
Non-Interventional Radiology			
Dept. Control / Work Area	250	1	250
Dark Room	120	1	120
Film Processing	120	1	120
Digital Closet	60	1	60
Active Film / File Holding	240	1	240
Reading Room	200	1	200
Mobile X-Ray Storage	60	1	60
Office	120	1	120
Toilet	55	4	220
Nuclear Medicine	160	1	160
Hot Lab	120	1	120
CT Heart Scan Exam Room	400	1	400
CT Computer Equipment Room	220	1	220
CT Control Room	150	1	150
Radiofluoroscope Exam Room	350	1	350
MRI Exam Room	425	1	425
MRI Computer Equipment Room	300	1	300
MRI Control Room	150	1	150
MRI / CT Injection Holding Room	80	1	80
Inpatient Stretcher Holding	80	2	160
Staff Facilities	1,200	1	1,200
Staff Toilet & Shower	440	1	440
Conference	240	1	240
Subtotal			5,785

Space / Function	Number of Rooms	Square Feet Per Room	Required Net S.F.
Interventional Radiology			
Cardiac Catheterization Lab	600	3	1,800
C.C. Control Room	200	3	600
C.C. Equipment Room	100	3	300
C.C. Film / File Hold	120	1	120
Visitor Gown Closet	40	1	40
C.C. Equipment Storage	280	1	280
C.C. Work Core	750	1	750
C.C. Family Waiting (20 Seats)	300	1	300
Electro-physiology Lab	600	1	600
E.P. Core and Supplies	400	1	400
Soiled Utility	140	1	140
Clean Utility	140	1	140
Housekeeping Closet	40	1	40
Subtotal			5,510

Space / Function	Number of Rooms	Square Feet Per Room	Required Net S.F.
Interventional Radiology Staff Support			
Office (Director of Cath Lab)	120	1	120
Office (Medical Director)	120	1	120
Staff Locker / Toilet	300	2	600
Staff Lounge	200	1	200
Gown Storage	40	2	80
Physician Viewing / Dictation	200	2	400
Digital Closet	30	2	60
Consultation	100	2	200
Conference Room	200	1	200
Subtotal			1,980

Space / Function	Number of Rooms	Square Feet Per Room	Required Net S.F.
Surgery			
Operating Room	600	4	2,400
Sub-Sterile Room	80	4	320
Set-Up Room	100	4	400
Nurse Control	150	1	150
Patient Prep / Hold	80	6	480
Clinical Instrument Department	100	1	100
Anesthesia Work Room / Storage	140	1	140
OR Equipment Storage	350	1	350
Pump Storage	120	1	120
Decontamination	120	1	120
Sterile Wrap	140	1	140
Sterile Storage	600	1	600
Soiled Utility	140	1	140
Clean Utility	140	1	140
Housekeeping Closet	40	1	40
Subtotal			5,640

Space / Function	Number of Rooms	Square Feet Per Room	Required Net S.F.
Surgery Staff Support			
Office (Director of Surgery)	120	1	120
Office (Medical Director)	120	1	120
Staff Locker / Toilet	300	2	600
Staff Lounge	200	1	200
Gown Storage	40	2	80
Physician Viewing / Dictation	200	2	400
Digital Closet	30	2	60
Consultation	100	2	200
Conference Room	200	1	200
Subtotal			1,980

Space / Function	Number of Rooms	Square Feet Per Room	Required Net S.F.
Emergency			
Walk-In Entry	75	1	75
Waiting (12 Seats)	180	1	180
Toilet	55	2	110
Reception / Admitting	150	1	150
Consulting Office / Triage	100	1	100
Nurse Control Station	150	1	150
Soiled Utility	120	1	120
Clean Utility	120	1	120
Equipment Storage	180	1	180
Trauma Room	340	2	680
Observation Room	140	2	280
Staff Lounge	180	1	180
Staff Toilet	55	1	55
Housekeeping Closet	40	1	40
Subtotal			2,420

Space / Function	Number of Rooms	Square Feet Per Room	Required Net S.F.
Laboratory / Genetics			
Lab Area	350	1	350
Blood Storage	100	1	100
Lab Receiving	65	1	65
Lab Storage	100	1	100
Office	100	1	100
Toilet	55	1	55
Blood Analysis Lab	100	1	100
Subtotal			870
Respiratory Therapy			
RT Work Area	120	1	120
RT Equipment Room	300	1	300
RT Wash / Assemble	180	1	180
Subtotal			600

Space / Function	Number of Rooms	Square Feet Per Room	Required Net S.F.
Inpatient Area			
Universal Patient Room (one bed w/ toilet)	350	60	21,000
Nurse Control Station	120	8	960
Crash Cart Alcove	15	8	120
Medication Room	60	8	480
Nourishment Room	80	4	320
Dictation / Reading Room	120	8	960
Stretcher Storage Alcove	70	4	280
Clean Workroom	150	4	600
Equipment Storage	200	4	800
Soiled Utility	150	4	600
Toilet, Staff	60	8	480
Staff Facilities Room	400	4	1,600
Physician Office	200	4	800
Janitor Closet	80	4	320
Conference Room	200	4	800
Subtotal			30,120

Space / Function	Number of Rooms	Square Feet Per Room	Required Net S.F.
Family Services			
Family Waiting Room	500	4	2,000
Toilet, Public (WC & Lav)	60	8	480
Consultation Room	100	4	400
Telephone Alcove, Public	10	4	40
Meditation Room	120	4	480
Chapel	300	1	300
Kitchen	240	4	960
Subtotal			4,660
Business & Administration			
Reception / Waiting (8 seats)	250	1	250
Office (Administration)	150	6	900
Office (Business)	120	3	360
Toilet	55	2	110
Break Room	120	1	120
Copy / Mail Room	300	1	200
Conference Room	250	1	250
Storage Room	180	1	180
Housekeeping Closet	100	1	100
Pay Station	120	1	120
Open Work Area	400	1	400
Subtotal			2,990

Space / Function	Number of Rooms	Square Feet Per Room	Required Net S.F.
Medical Records			
Office	120	1	120
Receiving / Viewing	120	1	120
Open Work Area	240	1	240
File Storage	200	1	200
Film Storage	500	1	500
Digital Closet	100	1	100
Copy Room	150	1	150
Subtotal			1,430
Building Services & Engineering			
General Storage	1,500	1	1,500
Housekeeping (Main)	200	1	200
Housekeeping Office	120	1	120
Employee Locker Room	300	2	600
Waste / Trash / Recycling Hold	480	1	480
Electric Room (Main)	180	1	180
Chiller / Boiler Room	2,500	1	2,500
Plans / Copy Room	160	1	160
Shop	350	1	350
Computer Room (Mainframe)	240	1	240
Subtotal			6,330

Space / Function	Number of Rooms	Square Feet Per Room	Required Net S.F.
Central Sterilization, Processing and Supply			
Soiled Receiving	540	1	540
Decontamination Area	300	1	300
Preparation and Packaging Area	800	1	800
Sterilization Area	1,200	1	1,200
Storage and Equipment Holding	1,000	1	1,000
Equipment Processing Area	660	1	660
Subtotal			4,500

PROPOSAL

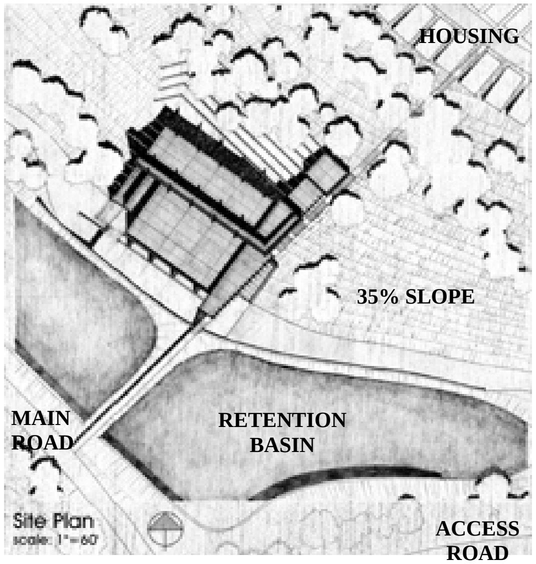

Figure 122. Hospital Site Plan.

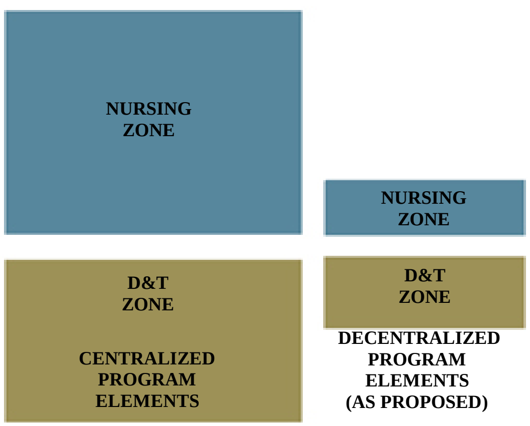

Figure 123. Size comparison between centralized and decentralized hospital program.

The design of heart hospitals, places where some of the sickest patients and most advanced medical care can be found, should accommodate and employ technology in ways that are both therapeutic and enabling. The heart hospital is prone to being disorienting, inflexible and confining and thus taking away comfort and control from the patient. The proposal for this heart hospital is designed to utilize the advantages associated with information technology and decentralization. The design was explored on four levels of detail including the hospital in its context, the programmatic organization of the hospital, overall hospital structure and massing as well as a detailed design of the individual patient room.

First, a decentralized design solution calls for a horizontal or vertically stratified scheme.   Since there were a number of strategically beneficial locations, an unconventional site was selected with difficult physical constraints and topological handicaps which dictated a vertically stratified hospital model. The opportunity was to take a challenging site and design a hospital with therapeutic value from the very few

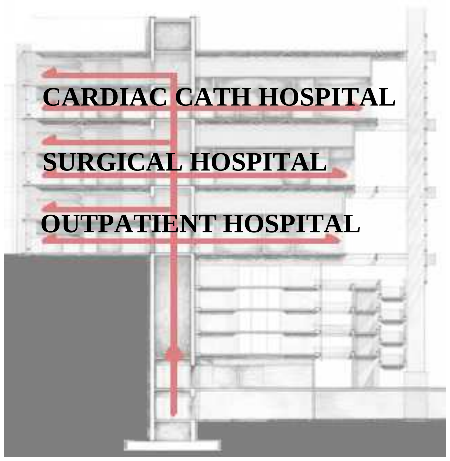

Figure 124. Vertically Stratified Centers of Excellence.

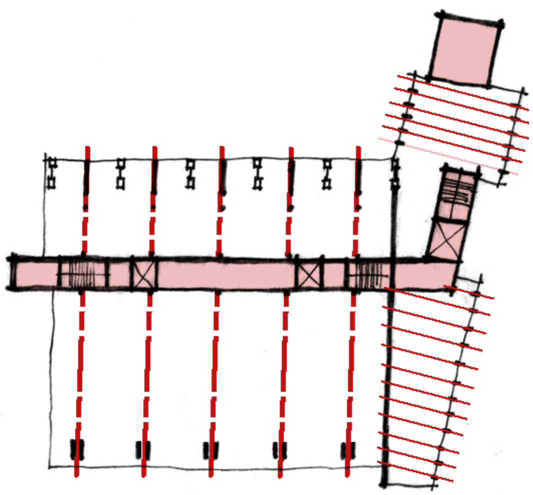

Figure 125. Regular and orderly framework.

notable inherent site qualities.

The second level of design explores how the decentralized heart hospital takes advantage of smaller and thinner building floor plates. Through decentralization, there is the ability to programmatically create a hospital within a hospital. Traditionally, hospitals that have centralized departments are thicker and have a more widespread mass, especially with respect to diagnostic and technology areas. This proposal will explore the ability to create a thinner and less massive floor plate by splitting up centralized departments and spreading them throughout each of three centers of excellence within the heart hospital. The three cardiac care service lines of focus are an Outpatient Hospital, Surgical Hospital and Cardiac Catheterization Hospital.

The third level of the proposed design examines the overall hospital structure and massing. The heart hospital is designed with an orderly, regular and predictable framework that enables simple, clear and direct paths while also retaining flexibility

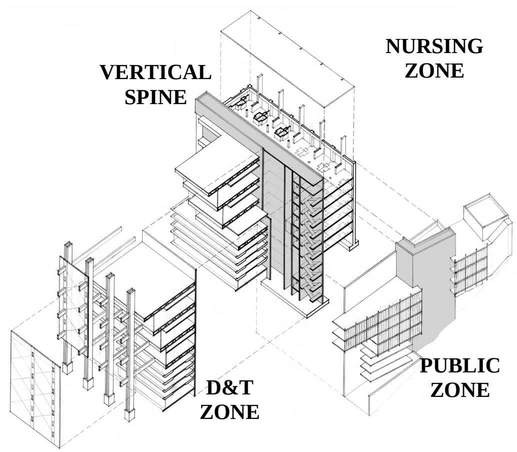

Figure 126. Hospital Zones.

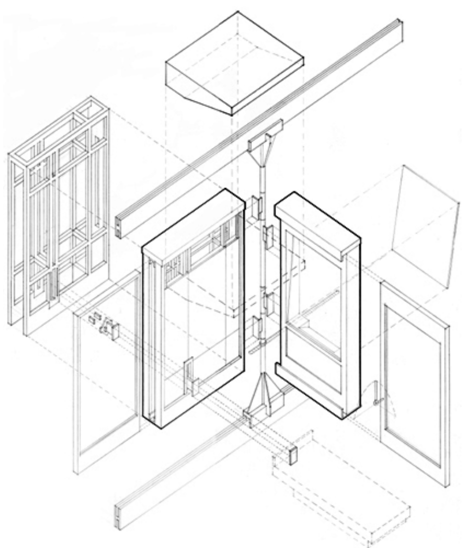

Figure 127. Detail of Patient Apparatus.

to accommodate technological change and growth of medical equipment and medical practices. There are three zones within this hospital; the diagnostic and technology (D&T) zone, nursing or inpatient zone and administrative support zone. The zone with the greatest amount of susceptibility to technological change is the D&T zone and is therefore designed with the most flexibility. The inpatient zone is strategically placed to take advantage of views of the northeast slope of the site which is an area with the most therapeutic value.

Lastly, this heart hospital employs simple mechanisms within the patient room that enable control over devices which can alter and improve physical aspects of the environment in which the patient spends the most time. The focus of this technological implementation is within the universal private patient room. The design centers around an “L” shaped partition called the Patient Apparatus which includes a nurse work station, medical gases and equipment. It moves within the patient room and tailors the environment to meet patient’s physical and psychological needs.

Decentralized Hospital and Unconventional Sites

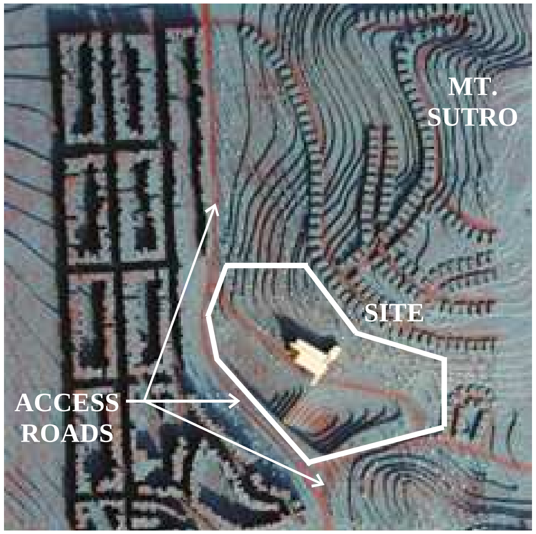

Figure 128. Context & Contour Model of Site.

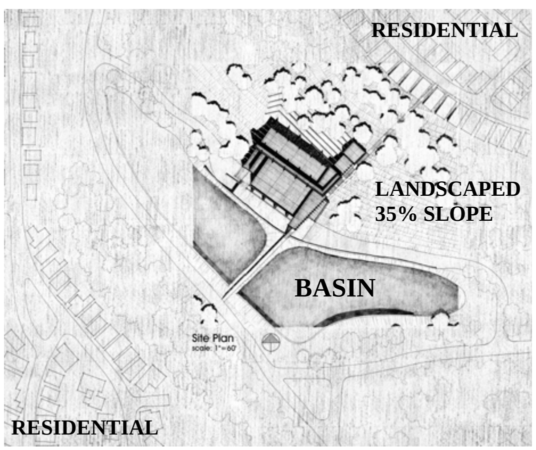

Figure 129. Hospital Site Plan.

As discussed in the previous chapter, the location of this site is primarily strategic. It is centrally located within the San Francisco Peninsula and provides access from several major arterial roads to a potentially diverse demographic base. The land is a relatively small parcel that is currently open which, in this otherwise desirable part of San Francisco, can be attributed primarily because of the steep slope, small area for building and configuration of the site. As shown in Figure 128 and 129, the site at the base of Mount Sutro has difficult and sloping terrain that falls to a pit of water that provides storm water retention for the area. The primary access road encompasses this retention area on the west and south sides leaving only a small, curvilinear sloping parcel of land on which to build. Without severely disrupting the existing physical composure of the site, there is very little available land.

A horizontal building layout or arrangement, which could be attained on larger and flatter land, is not feasible on such a physically dynamic site. A horizontal arrangement consumes much more land especially for larger programs because the compo-

Figure 130. Site Section showing sloping land and access from parking levels below hospital.

nents would be spread throughout the site. A vertical building arrangement reduces the amount of horizontal circulation and connectivity, which is advantageous for a site that slopes severely. Also, parking, access and widespread site circulation can be difficult to accommodate on a difficult and steep site without a tremendous amount of cutting, filling and sculpting of the land. A more appropriate design solution would be to compact the parking by stacking in a structure.

Based on what land is left over on this site, the most appropriate application and structural layout for this particular heart hospital is a vertically stratified arrangement. Figure 130 represents a vertically stratified hospital arrangement lifts the building components off of the delicate site, minimizes intrusion on the land as well as preserves some of the natural landscape of the northeastern slope. This natural landscape which contains old growth trees and native plant species also offers therapeutic potential to the inhabitants of the hospital. This vertical arrangement also allows preservation of the existing retention basin, site drainage and water flow. A parking structure and central plant is tucked underneath the primary components of the building, minimizing site development, paving and other intrusions on the natural landscape. Also, parking, drop-off and circulation to the building is simplified as these spaces are linked to the upper portions of the hospital by various elevators placed through the infrastructure.

Decentralized Hospital and Smaller Building Footprints

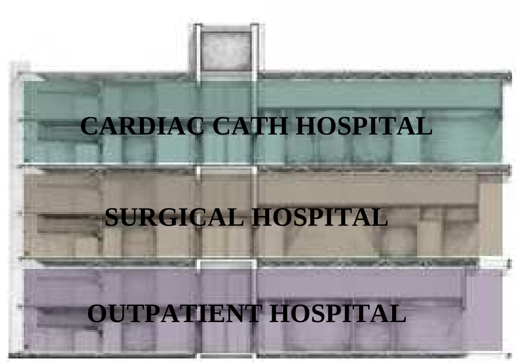

Figure 131. Three Main Hospital Service Lines or Centers of Excellence.

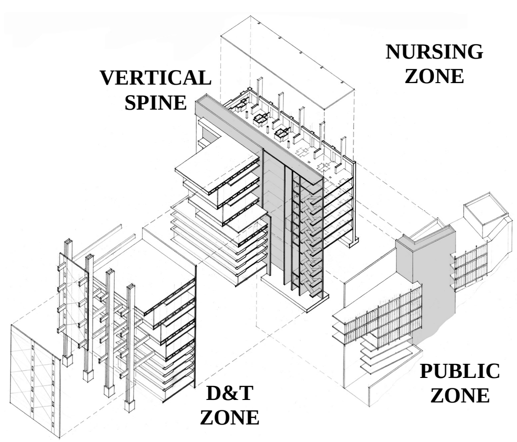

Figure 132. Components of hospital.

This proposal utilizes the advantages associated with decentralization due to widespread use of information technology employed throughout the hospital. Programmatically, the departments that compose a decentralized hospital are divided up and scattered to serve a distinct specialty service line. For this proposal, there are three main service lines or centers of excellence which include outpatient clinics, surgical suites and cardiac catheterization laboratories (Figure 131). Each service line focuses on a specific diagnosis or treatment of an illness as well as specific patient population. This focus allows the cardiac care hospital services to be separated into “mini hospitals” or “hospitals within a hospital.” As shown in Figure 132, each hospital floor has three main programmatic components which include a diagnostic and technology zone, an inpatient or nursing zone as well as a public and administrative zone. Subdividing the zones is a central utility, elevator and service spine that serves all components on each floor.

As discussed previously, the site warrants vertical stratification of the three hospitals

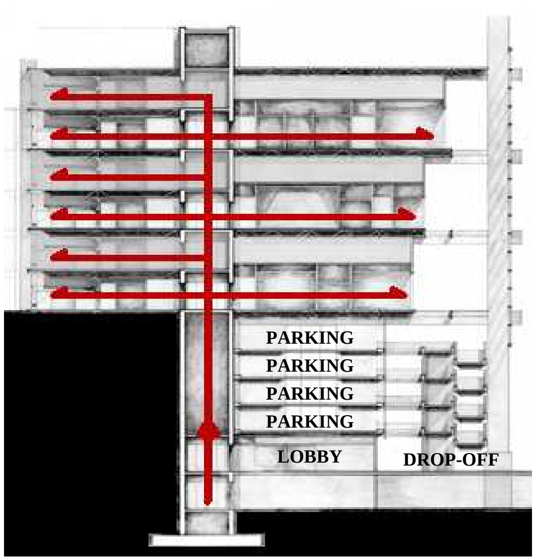

Figure 133. Vertical travel through hospital.

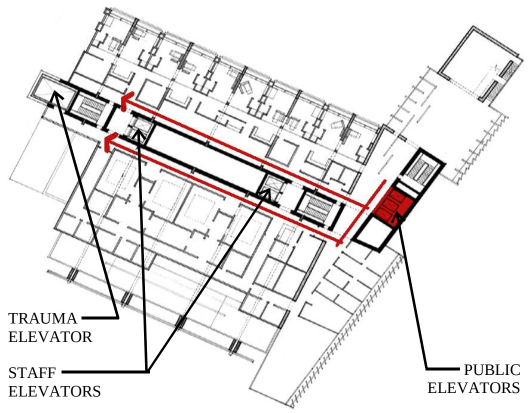

Figure 134. Horizontal travel through hospital.

within a hospital. Vertical stratification allows a compact building form that relies predominantly on up and down circulation through the building. A significant advantage to this is the user having to rely on elevators to guide them along a portion of their route, thus simplifying the experience. When the patient or visitor arrives, the majority of their visit will be located on a single floor in one of the three distinct specialty hospitals. A clinical advantage is that the patient can have a majority, if not all, of their care performed on one floor, thus minimizing their movement throughout the hospital. For patients and visitors, this movement begins at the drop-off or one of the parking levels beneath the building. From here, circulation is directed to a lobby where elevators connect to the waiting room at any of the upper level specialty services (refer to Figure 133). Staff movement is similar, except connection to upper floors is provided from service core elevators separate from the public. In addition, a trauma elevator has been provided for emergency cases that also has a separate entrance and connection at all upper floors. Also as shown in Figure 134, clear wayfinding for the patient and visitor is also provided by straight and direct horizontal

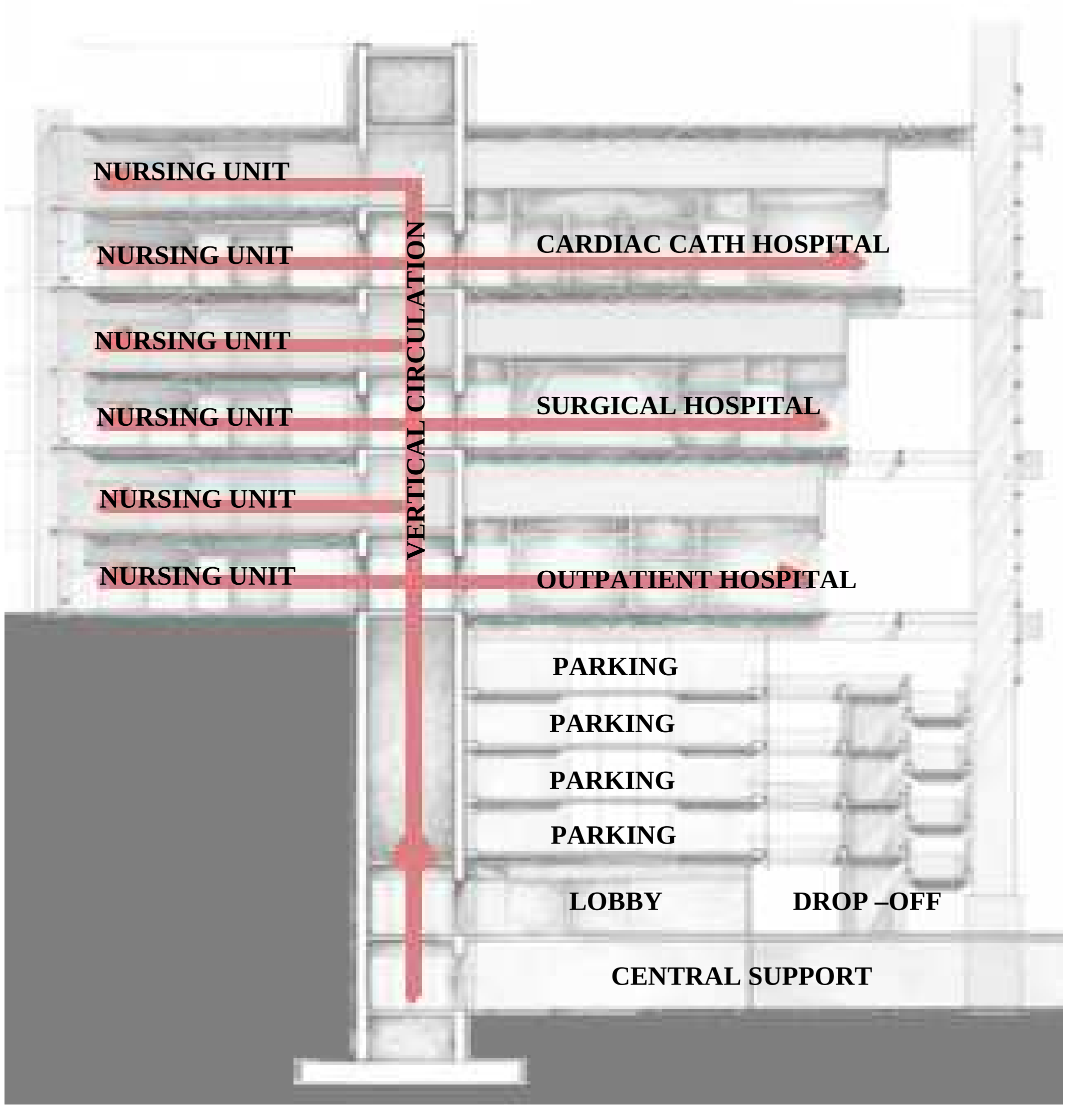

Figure 135. Building Cross-Section showing vertically stratified hospital services.

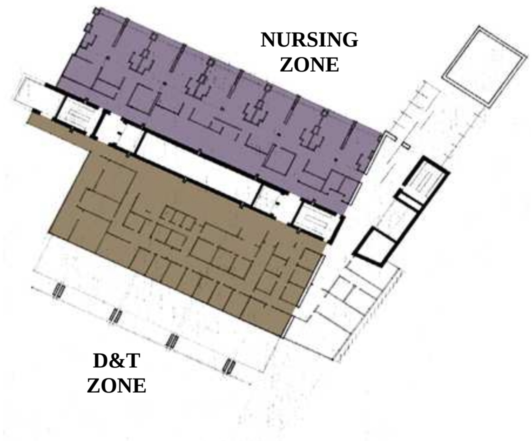

Figure 136. Outpatient Hospital.

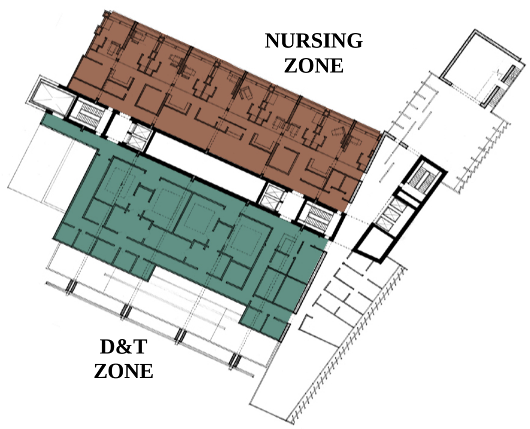

Figure 137. Surgical Hospital.

movement from the waiting room to the patient wing or diagnostic and technology block.

In this vertically stratified model shown in Figure 135, the specialty service that is lowest to the ground level drop-off and parking decks is the Outpatient Hospital on the 6th and 7th floors (Figure 136), which typically has the greatest degree of turn-over throughout the day from a patient perspective. Procedures in this hospital may last as little as thirty to sixty minutes. Therefore the placement closest to the parking area minimizes travel time on the elevator and limits outpatients interacting with in-patients. The floors above the Outpatient Hospital are the Surgical Hospital on the 8th and 9th floors (Figure 137) and the Cardiac Catheterization Laboratory which oc-cupies the highest levels of the building, the 10th and 11th floors (Figure 138). Travel time on the trauma elevator influenced the stacking of these services as these type of elevators are typically slower than passenger or patient type elevators. Trauma cases, which are often admitted to an emergency room, can be transported di-

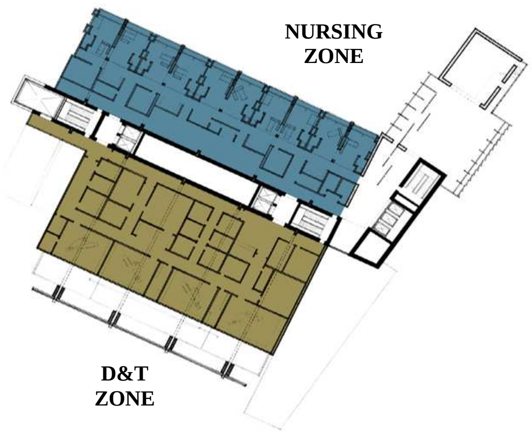

Figure 138. Cardiac Catheterization Hospital.

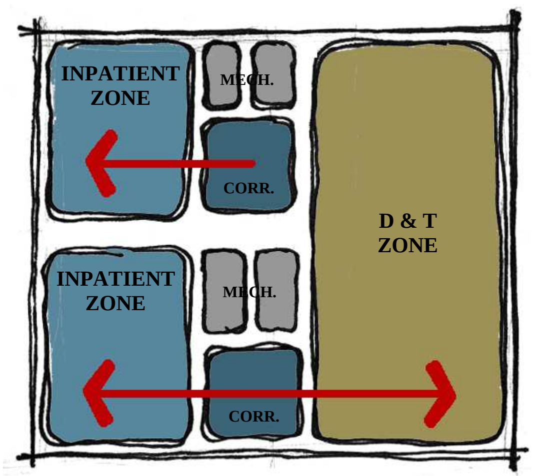

Figure 139. Two-story D & T Zone.

rectly to surgery or a catheterization lab after stabilization. In greater emergencies, patients will be taken directly to surgery, where invasive open-heart procedures may be performed. In these cases it is best to minimize travel time

Each hospital within a hospital or center of excellence occupies two stories with a double-height diagnostic and technology floor on one side that corresponds to two floors of patient beds on the other (Figure 139). These segregated centers of excellence help minimize the spatial experience that patients, visitors and staff have within the entire hospital. It also provides for better care by staff because the compact floor plate minimizes any critical time-motion adjacencies. For example, patients that are in a surgical patient room can be shuttled back to an operating room quickly. Also, patients in the catheterization lab can be sent to the surgical floor below in case of an emergency. The routes are compact and direct as the stacking minimizes horizontal walking movement and vertical movement in elevators help compensate for the remainder of the distance between services and floors. For this proposal, information technology and decentralization of the hospital has allowed a smaller building footprint that minimizes travel times, affords clearer wayfinding and maximizes clinical efficiency and care of patients.

Orderly and Flexible Building Frameworks

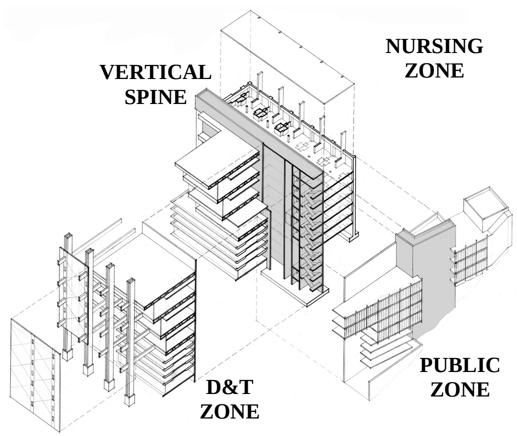

Figure 140. Building Axonometric.

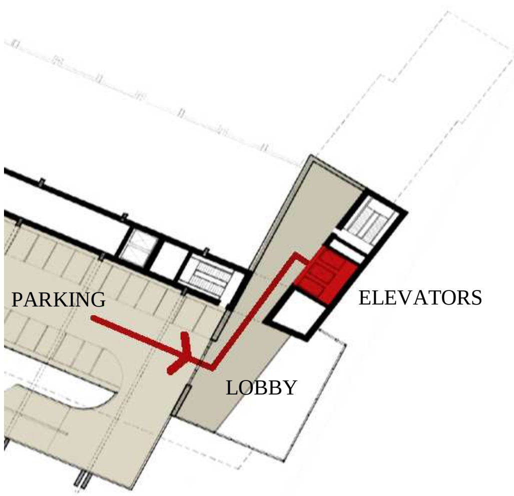

Figure 141. Parking and Upper Lobby: 2nd through 5th Floors.

Within each hospital, a simplified building framework further subdivides into components that organize traffic to provide clear and concise wayfinding routes. A vertical spine, shown in Figure 140, is the main organizing element of the framework for the hospital. It consists of conduits for the building mechanical services, exit stairs, vertical transport and trauma elevator. On one side of the floor plate is the double-height diagnostic and technology (D&T) zone and the other side is the nursing units. The third component, the administrative and public wing of the hospital, is shifted adjacent to the other two zones. The vertical stratification of the hospital and its division into zones simplifies the user experience so that spatial comprehension may be enhanced thereby providing more comfort and control through better wayfinding.

The experience for the user begins from the entrance concourse and moves to a set of elevator banks located within the public zone of the hospital. This can occur on the ground floor drop-off or through one of four parking decks that have a direct entry into the multi-story height lobby (Figure 141). All vertical transportation for visitors

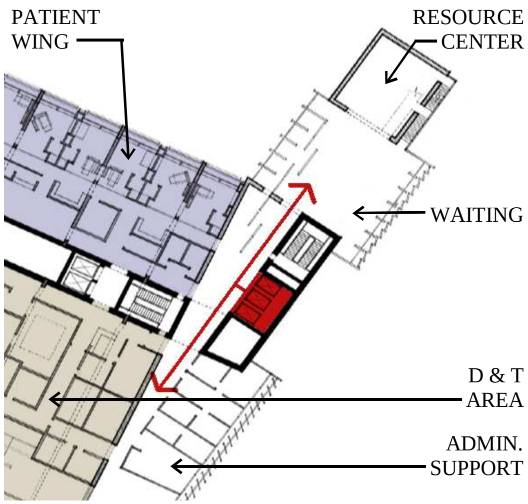

Figure 142. Plan Detail showing public access to hospital.

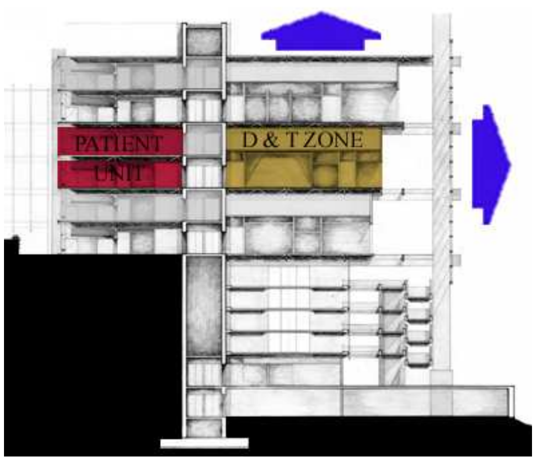

Figure 143. D&T expansion zones.

takes place within this part of the vertical circulation spine, where they can quickly and easily make their way to the upper floors. As shown in Figure 142, the user exits the elevator from the spine onto one of the upper floors and enters the department in a section of the public wing that also contains waiting areas and resource center, both located on the patient zone side of the spine. On the opposite side are the administrative support areas adjacent to the D&T zone.

On one side of the spine, the D&T zone has an open and flexible floor plate that can accommodate changes resulting from innovation in medical equipment and practices. Figure 143 shows that the floors can be added upward and expand outward infilling the area near the spine as well as behind the translucent exterior wall system, which acts as a constant shroud to the changes that occur. The shroud wall is the front façade of the hospital, which gives closure and finish to the work in progress in the diagnostic and technology zone (Figure 144). The interior of this zone is kept column free to avoid obstructions that would inhibit change. On the other side of this façade

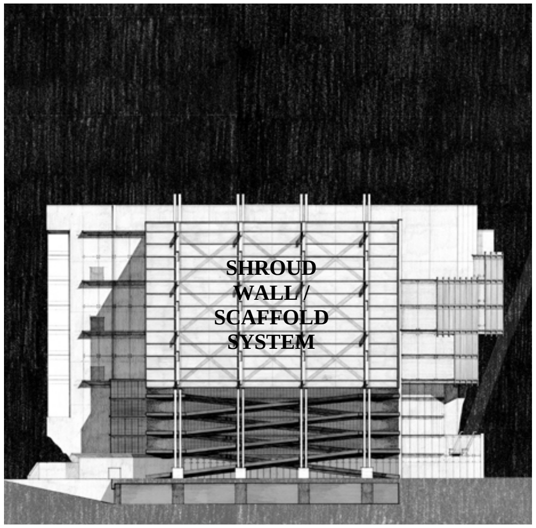

Figure 144. Front Elevation: D&T Zone Elevation showing shroud wall and exterior columns.

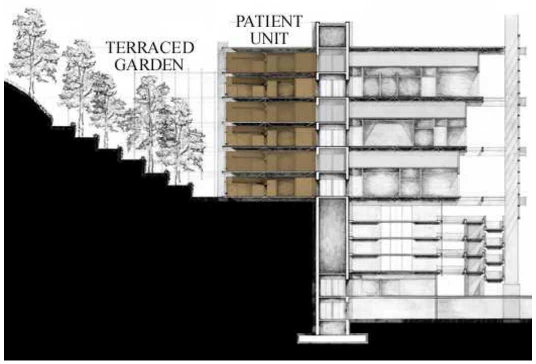

Figure 145. Patient unit view of terraced garden.

is a scaffold-type system that will receive the additional flooring and exterior wall that can vary in opacity in order to let the natural diffused light into the spaces beyond. In section, each double-height D&T floor incorporates an interstitial space above that helps facilitate and accommodate rapid change (refer to Figure 135).

On the other side of the spine is the nursing unit. The placement of the hospital is primarily driven by this component. Figure 145 shows that each floor of the nursing unit is facing directly into the most therapeutic portion of the site, which is a naturally landscaped and terraced garden. This view of the hill will enable an intimate view of nature for the occupants in the patient rooms. Since the hill is on the hospital property it less likely to change over time as opposed to a view of a landscape on another property.

From the entrance to the floor, visitors are taken down the semi-public corridor that is adjacent to the vertical circulation spine (Figure 146). Along this corridor are portals

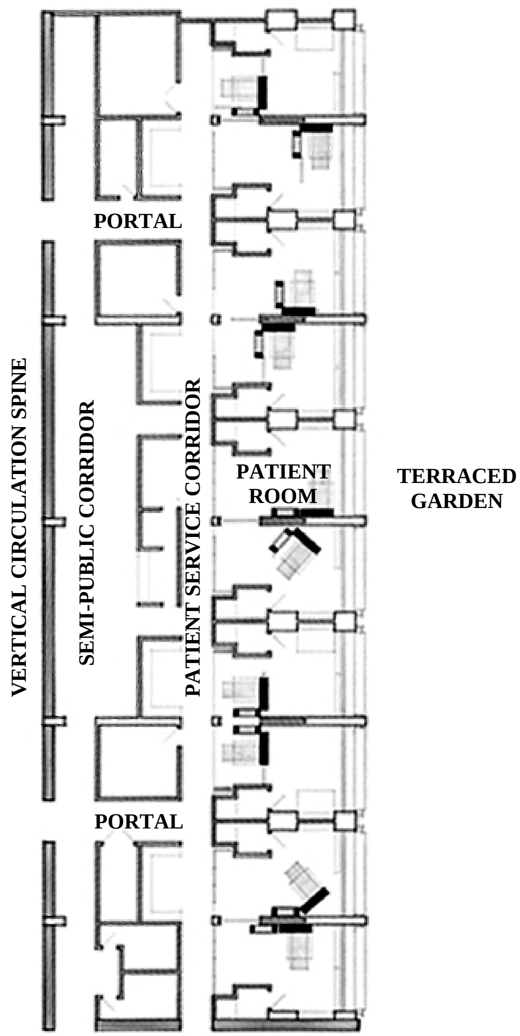

Figure 146. Detail Plan of Nursing Floor.

that connect it with the parallel, but more private, patient service corridor. A visitor's experience of what could be a rather disturbing I.C.U. scene is minimized to a couple of rooms instead of the entire wing.

The organization of the building into three main blocks, the D&T zone, inpatient zone and administrative and support zone, enables simplified organization of the building mass which helps facilitate expansion, accommodates technology and provides for clear wayfinding. The structural frame of the ever-changing D&T technology block is column-free and incorporates a scaffold-like system that can quickly accommodate additions and renovations. Likewise, the double-height D&T floor plate has a inter-stitial space that allows expedient alteration of mechanical and other technological systems. These systems are connected to a central service spine that acts as a conduit for this structure as well as future floors that may be added above. Finally, the most stable portion of the building - the nursing wing - is sited toward the terraced garden, maximizing patient and family exposure to the most therapeutic portion of the site.

The Reconfigurable Patient Room

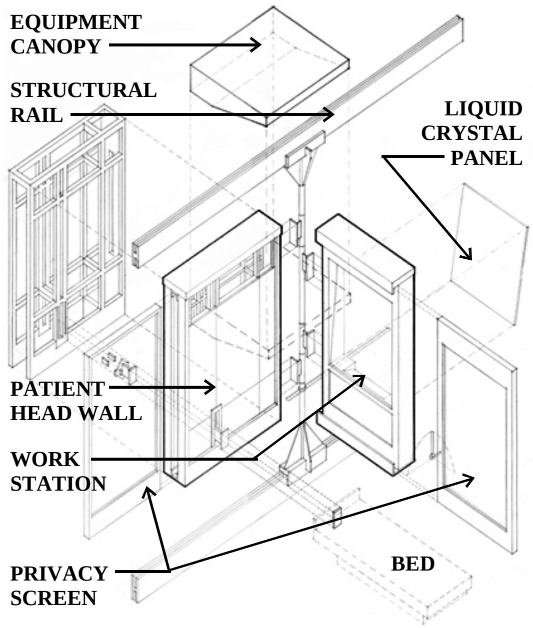

Figure 147. Patient Apparatus Axonometric.

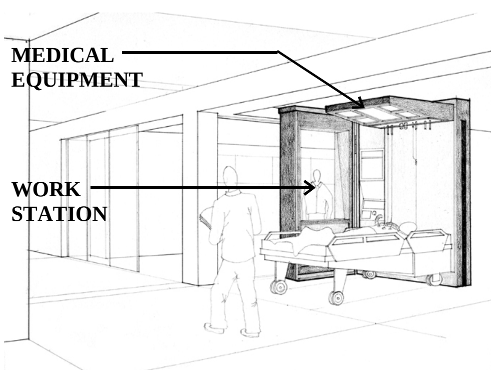

Figure 148. Perspective of Stage 1 Recovery.

The patient units allow for re-configurability and flexibility by way of a "patient apparatus" located within each patient room that, through the course of medical care, is able to mechanically change or alter the environment under the control of the patient (Figure 147). The "L" shaped Patient Apparatus is able to slide back and forth, pivot open and closed, or close off space for added privacy with the aid of liquid crystal glass panels. Nursing practices are accommodated through a workstation provided on the opposite side of the outside leaf of the apparatus. Another advantage to the apparatus is that the medical equipment, such as ventilator and monitor, can move with the patient as they adapt to their environment.

There are primarily four stages of health in which I.C.U. patients can be classified and which the Patient Apparatus can be reconfigured to accommodate according to the needs of the patient (see Figures 149 through 152). In the beginning stages, the patient who is unaware of their surroundings is kept out on the corridor for one-to-one, twenty-four hour personal monitoring. This works because the patient, although

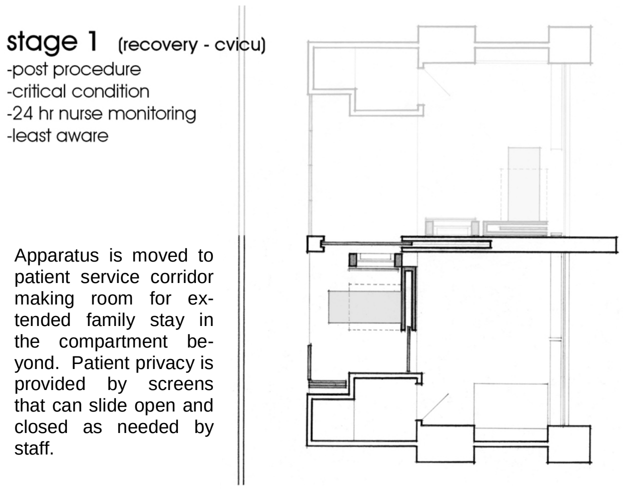

Figure 149. Stage 1 Apparatus Position.

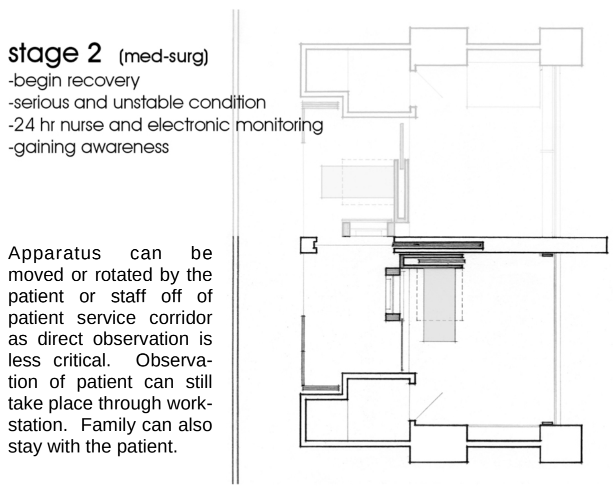

Figure 150. Stage 2 Apparatus Position.

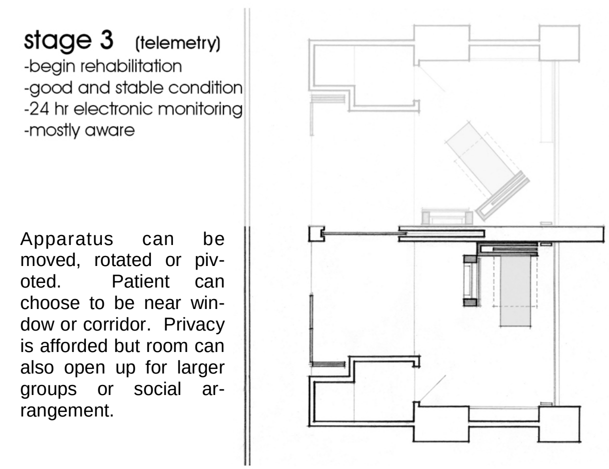

Figure 151. Stage 3 Apparatus Position.

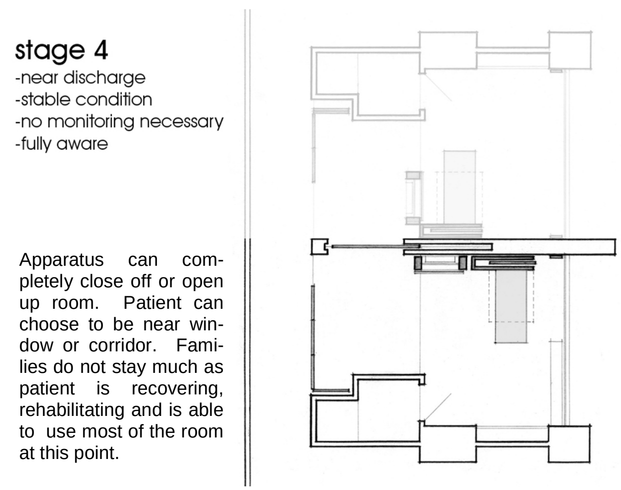

Figure 152. Stage 4 Apparatus Position.

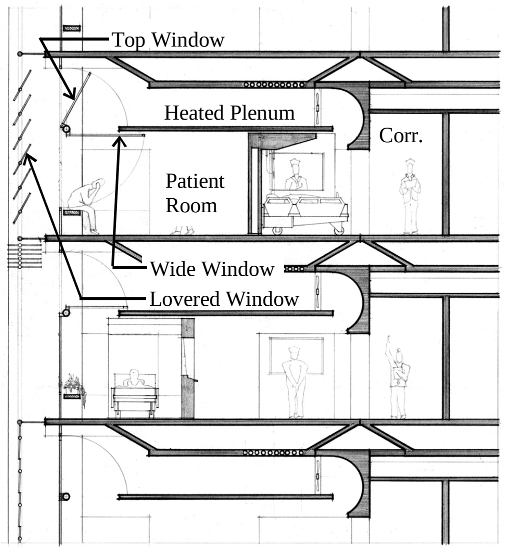

Figure 153. Detailed Section at Nursing Unit.

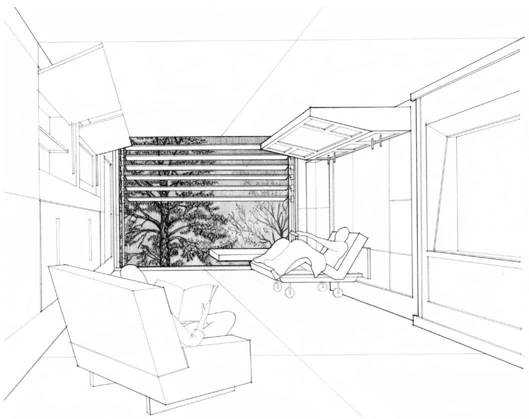

Figure 154. Perspective of patient room with landscaped terrace beyond.

exposed to the nursing corridor, is not aware of it, and a double corridor system has been designed within the infrastructure to minimize semi-public traffic through the ICU and past ill patients. Throughout their stay, the patient regains consciousness through stages two and three and eventually to stage four.

Patients also regain control of themselves and the ability to control their environment, and therefore the Patient Apparatus can be moved. The movable apparatus adjusts to also help optimize comfort for the patient as their health status, mobility and needs change. Comfort can be provided by allowing variable bed proximity to the exterior window wall. This window wall can open at the top to allow natural air to circulate through a heated plenum above the room and then back into the building near the service corridor. A portion of this window can also swing wide open with unobstructed views to the terraced landscape garden at the rear of the hospital. If privacy is desired from this exterior wall, a set of glass louvers with a translucent perforated pattern can be lowered or raised and pivoted up and down (Figures 153 and 154). The stages one through four vignettes in Figures 149 through 152 show the difference between the transformations of the patient rooms. Patients go from being highly visible to the corridor for high acuity care, to forming a room to be with families and visitors, to being within the room with family until discharge.

Each Patient Apparatus in the nursing wing is a technological instrument that enables the patient to control their room environment and maximize personal comfort. It allows the individual's room to be reconfigured to accommodate a patient's physical and psychological needs. Visual and acoustical privacy and exposure can vary to respond to more social situations with family members, clinical situations for care by nursing staff as well as adapt to times of personal solitude. The exterior envelope is interactive and adjustable to control views to the terraced garden beyond as well as exposure to nature, natural sunlight and airflow. The façade can be closed off or be fully open so the exterior space can become a visual and therapeutic extension of the patient room.

Conclusion

The proposed Heart Hospital for the Laguna Honda section of San Francisco illustrates how technology can enable sophisticated medical equipment and advanced medical practices to integrate with the most complex medical settings to help provide greater comfort and control to one of the most ill patient population. The “hospital within a hospital” that is enabled by decentralization allows a smaller and thinner floor plate that simplifies building massing and organization, and provides for better orientation and spatial comprehension. The hospital framework, which is regular and predictable, allows hospital technology to be changed out and added to easily over time while maintaining a clear wayfinding system. Within the nursing unit and individual patient room, controls are provided that allow the patient to reconfigure and adjust their surroundings as they recover so that they may suit their personal psychological and physical needs. This hospital employs technology in ways that are both therapeutic and enabling.

Most hospitals of today have accommodated technology in some way but the influ-

Figure 155. Intelligent Workplace.™

Figure 156. Debis Tower.

ence of technology on the architectural profession is arguably in its infancy. Information technology and the resulting decentralization of hospital support services are becoming more widespread. Accommodation of electrical, computer, wireless and I.T. systems as well as facility integrated medical equipment is slowly effecting how health care buildings are constructed, planned and organized. Building frameworks are more regularly being designed as open, flexible and expandable structures that can adapt to respond to technological need. However, architectural responses to technology in health care buildings are for the most part hidden within walls, rooms or above ceiling spaces and primarily benefit the patient and health care practices in an indirect way.

It is very rare to see any aspects of a interactive building system such as that employed at the Intelligent Workplace™ in a hospital setting nor is it common to see operable building facades that are frequently being used in commercial buildings such as the Debis Tower. Other than the associated costs of these systems and their impact on a hospital budget as well as the collective impact on overall escalating costs of health care in general, it would be worthwhile to study how patients in a hospital would react to the ability to use technological devices to control their hospital environment. American society is accustomed to technological devices such as computers, cell-phones, I-pods, video games as well as other technologies in our cars and homes. It is reasonable to assume that these would be just as acceptable in our health care settings of the future.

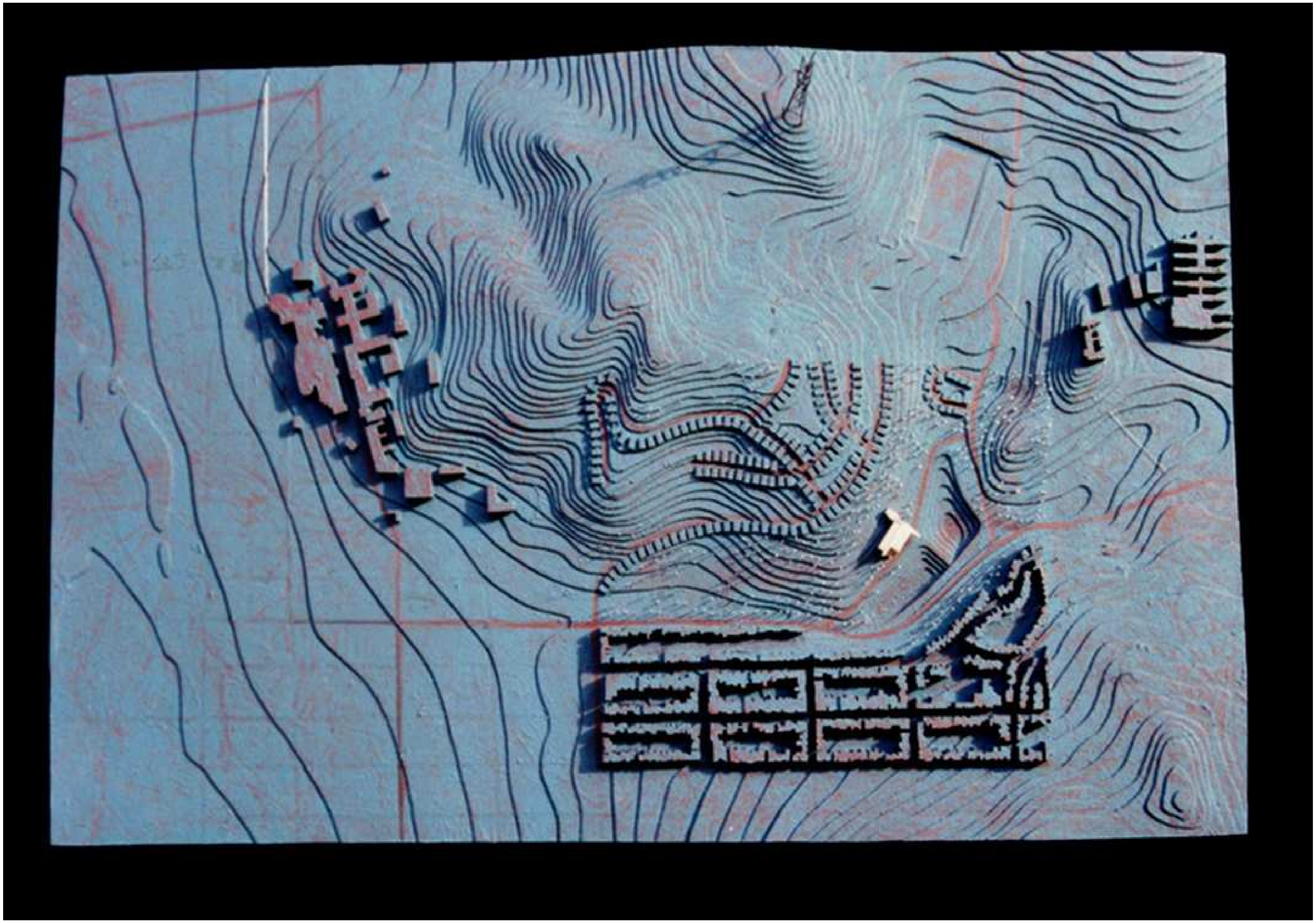

Figure 157. 1:200 Context Model.


Figure 158. 1:60 Building Model - Front View.

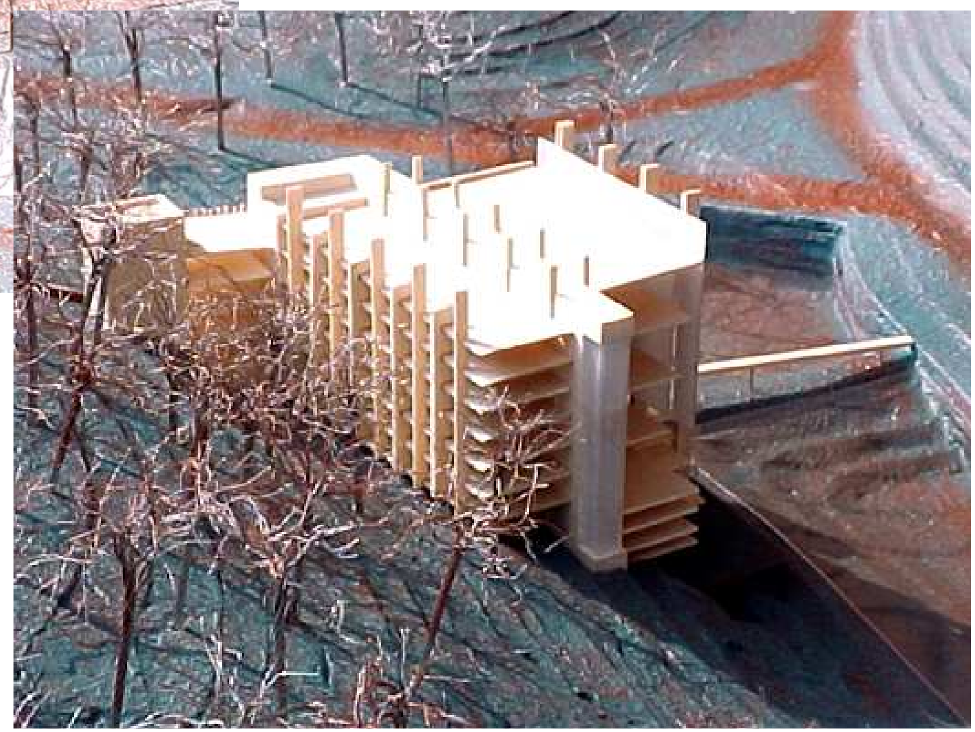
Figure 159. 1:60 Building Model - Rear View.

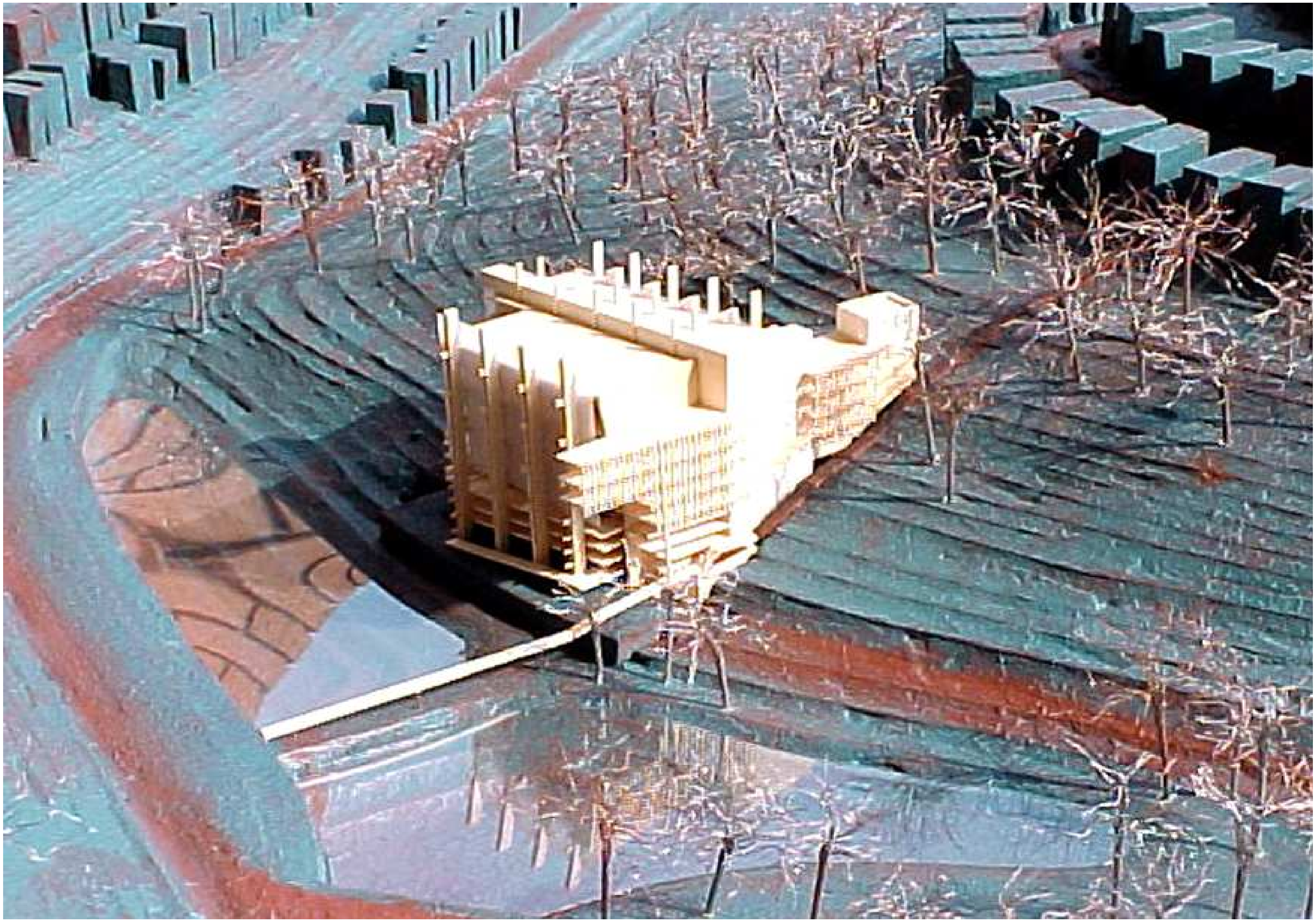

Figure 160. 1:60 Building Model.

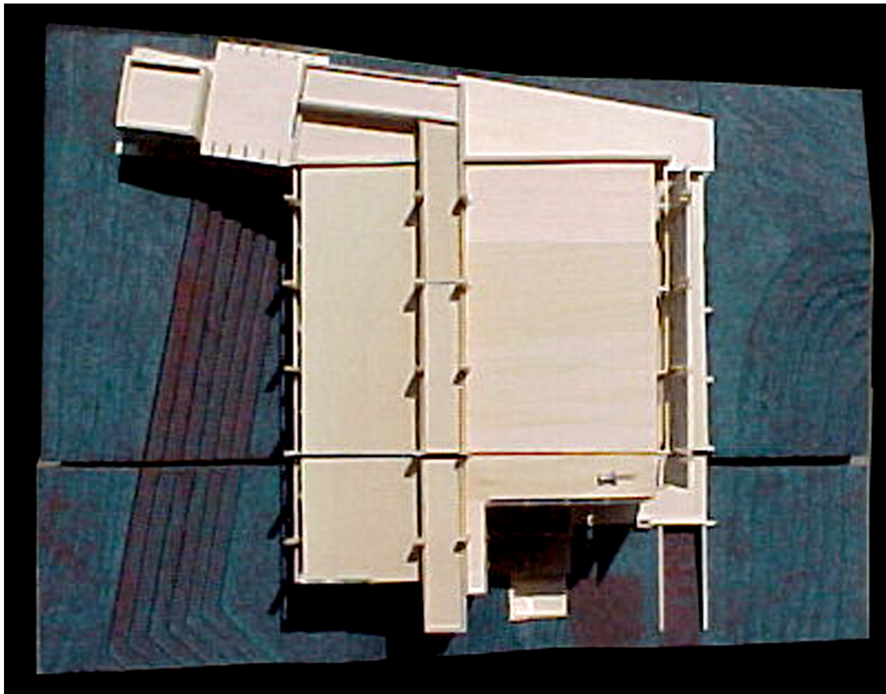

Figure 161. 1:16 Sectional Model - Top View.

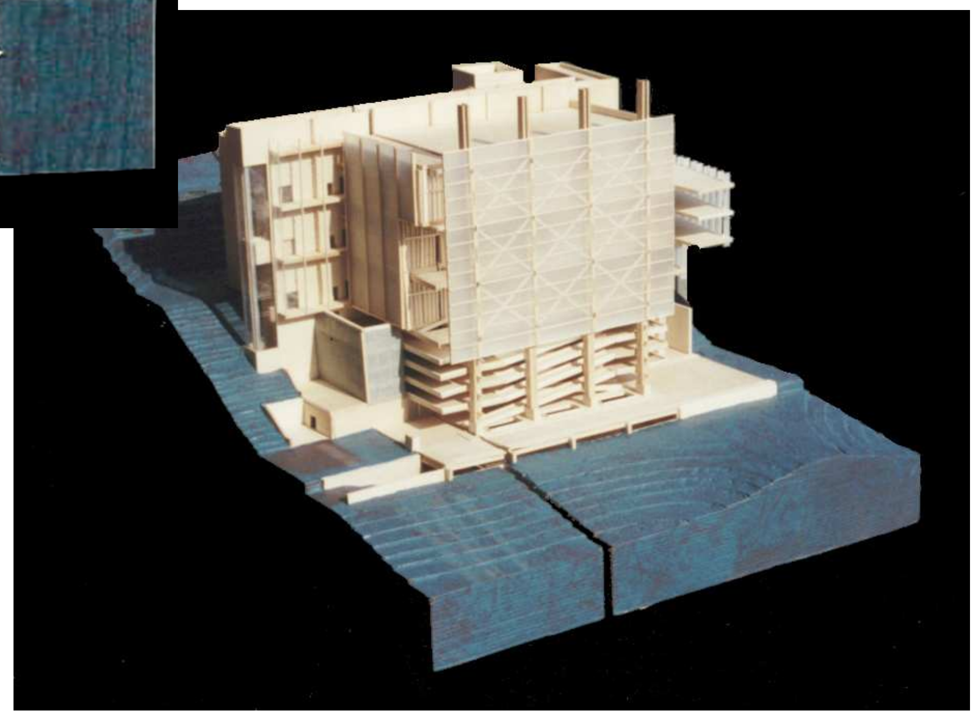

Figure 162. 1:16 Sectional Model - Front View.

Figure 163. 1:16 Sectional Model - Side View.

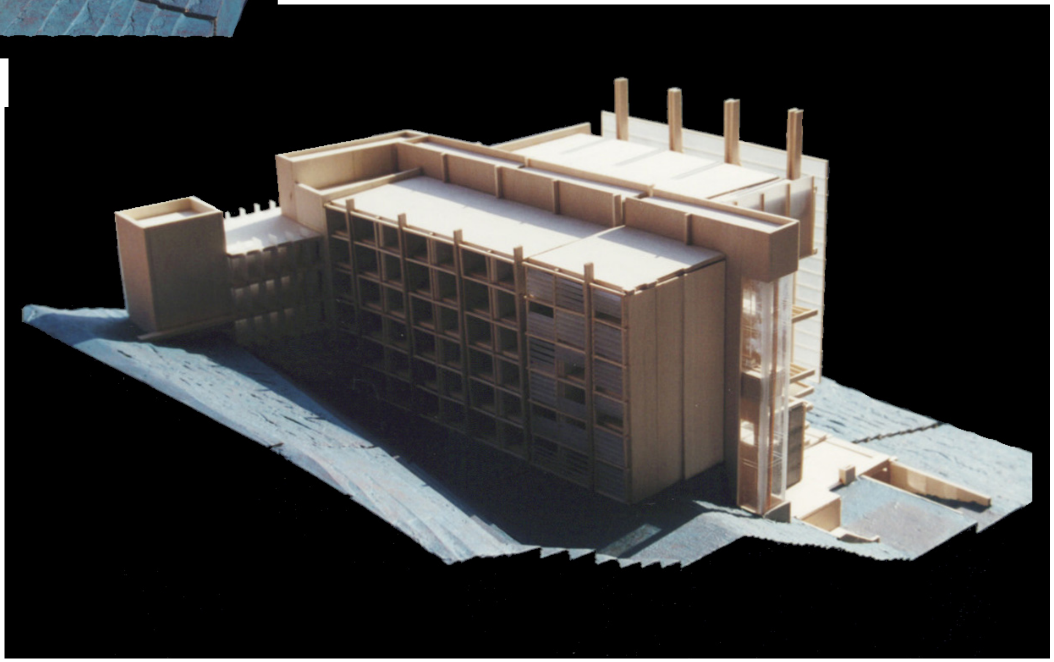

Figure 164. 1:16 Sectional Model - Rear View.

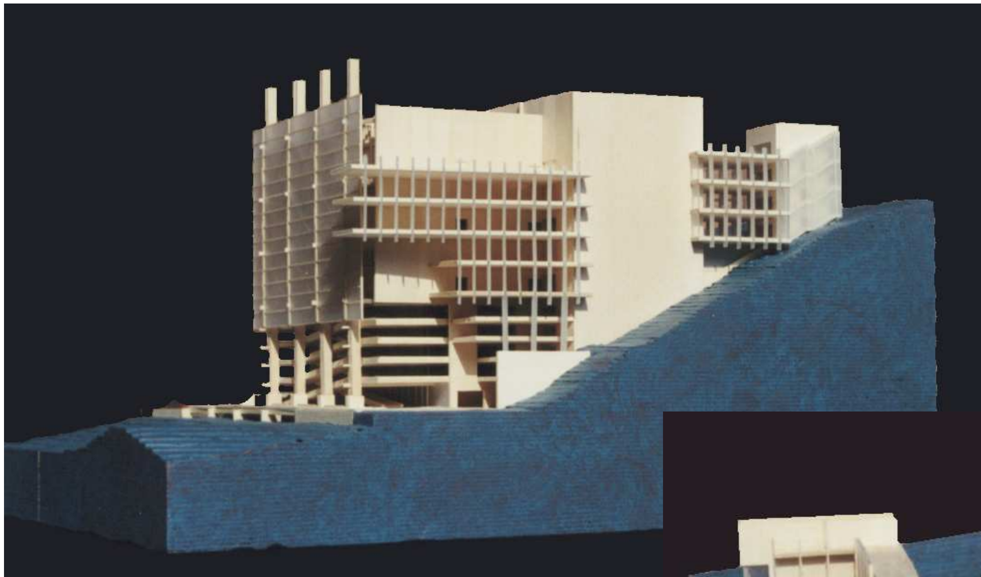

Figure 165. 1:16 Sectional Model - Side View.

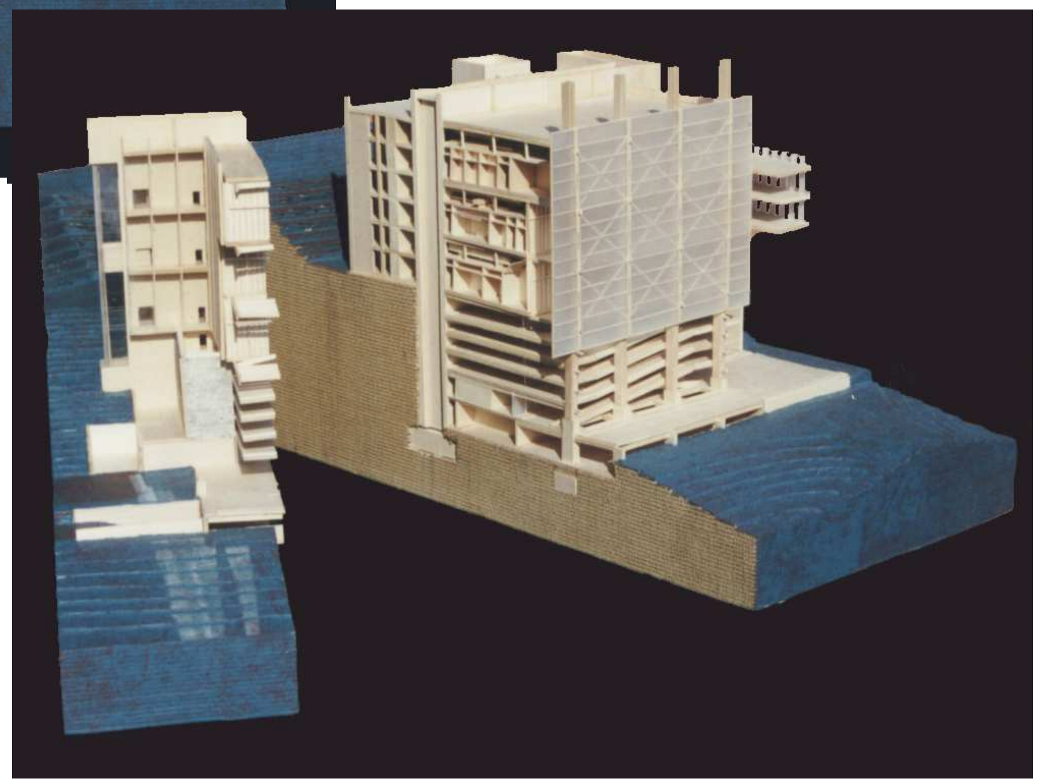

Figure 166. 1:16 Sectional Model - Split View.

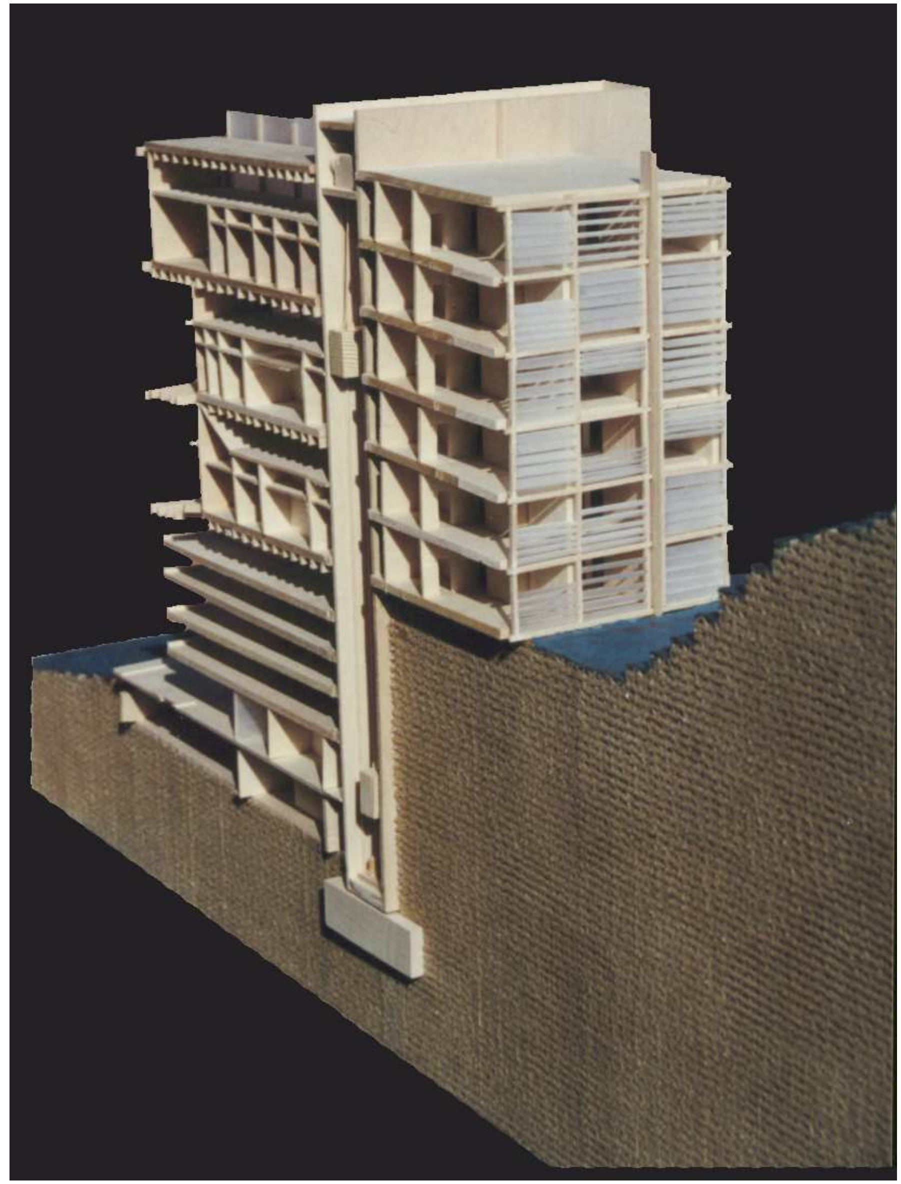

Figure 167. 1:16 Sectional Model - Split View.

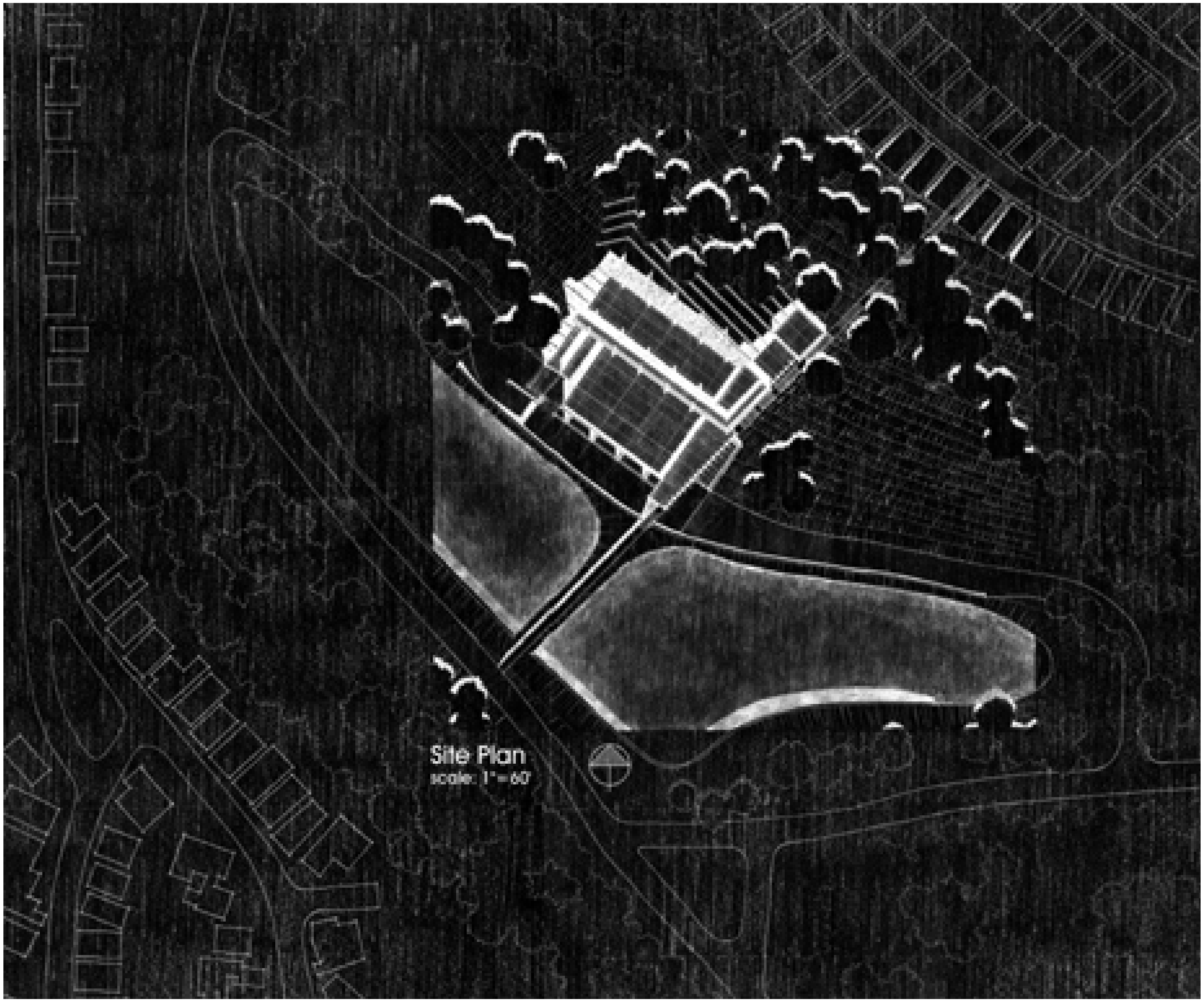

Figure 168. Site Plan.

Figure 169. Building Cross Section.

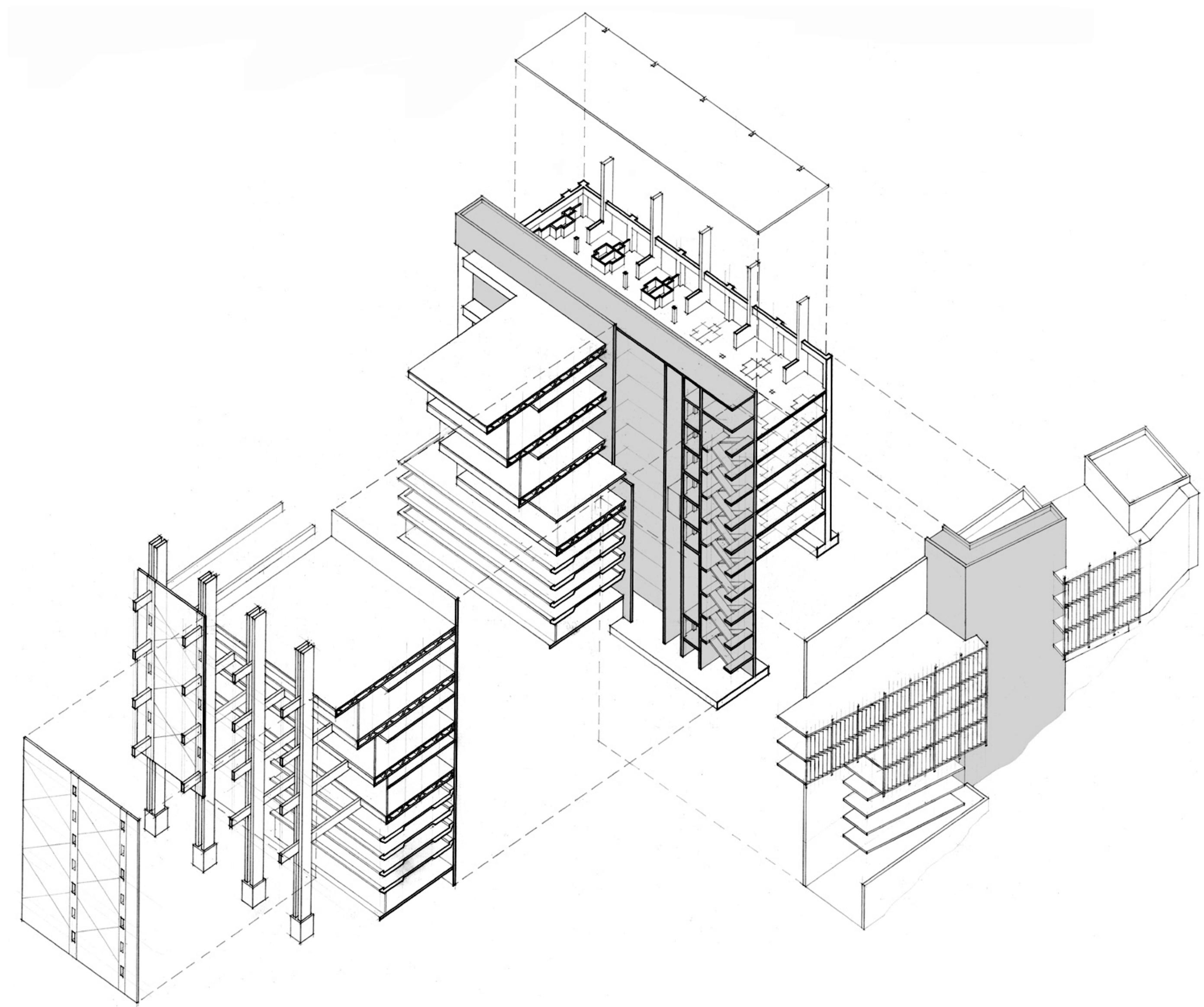

Figure 170. Exploded Building Axonometric.

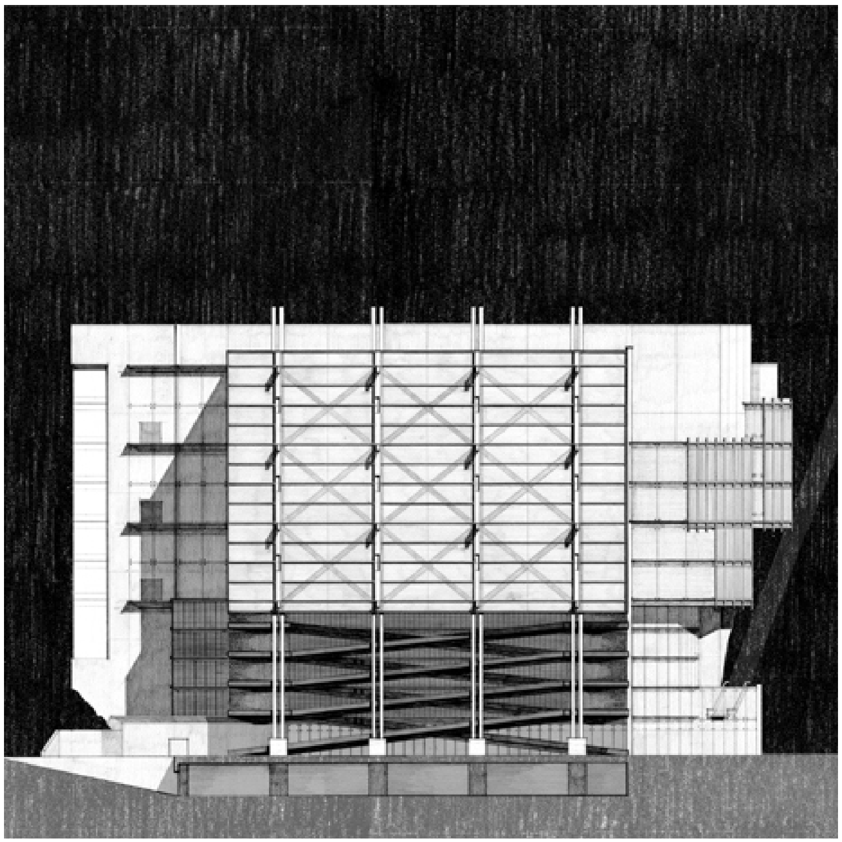

Figure 171. Front Elevation.

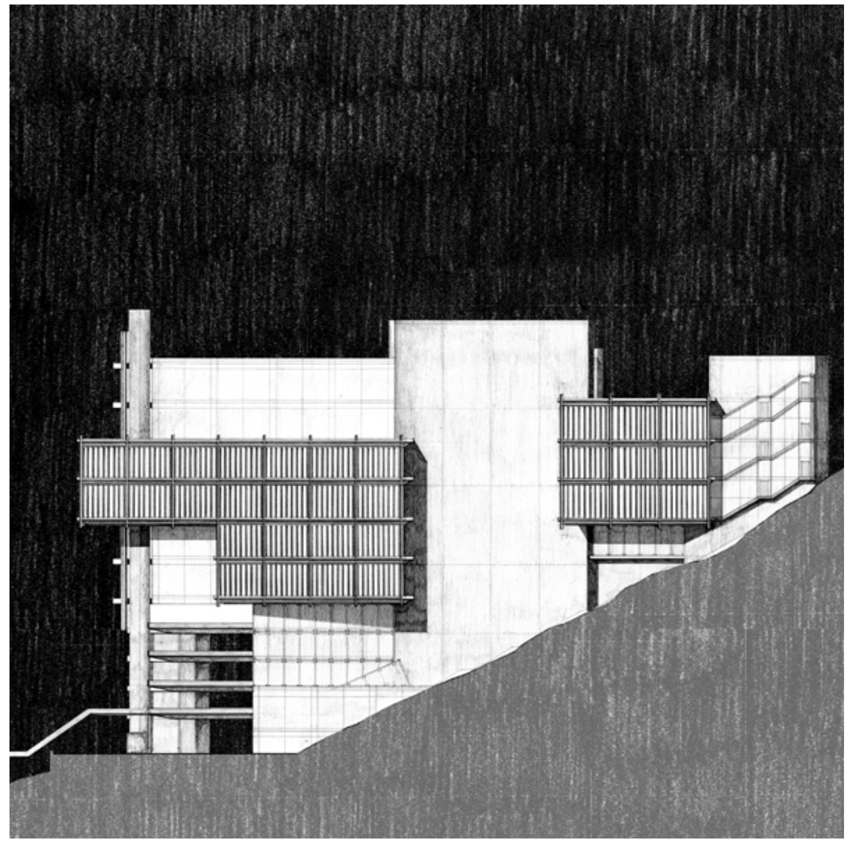

Figure 172. Right Side Elevation.

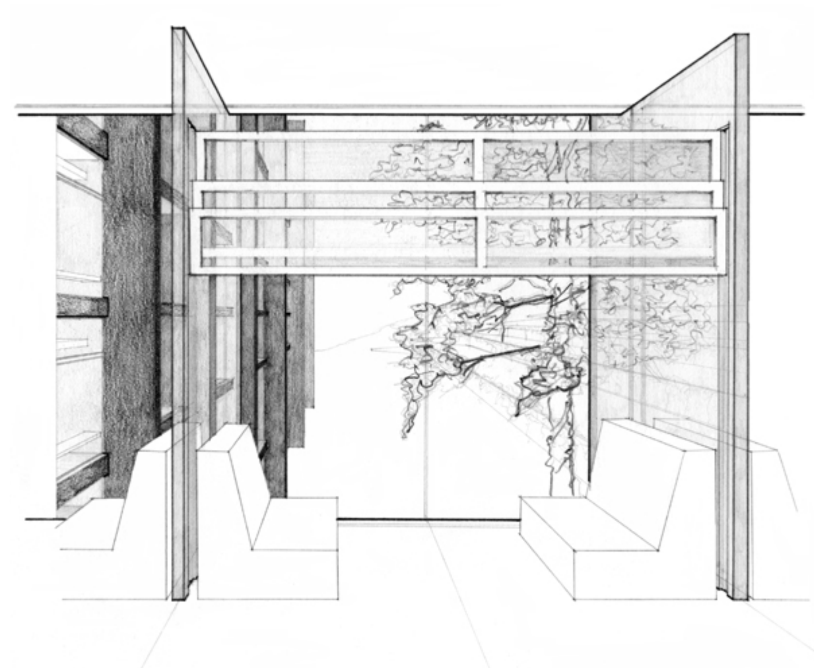

Figure 174. Perspective of Waiting Space

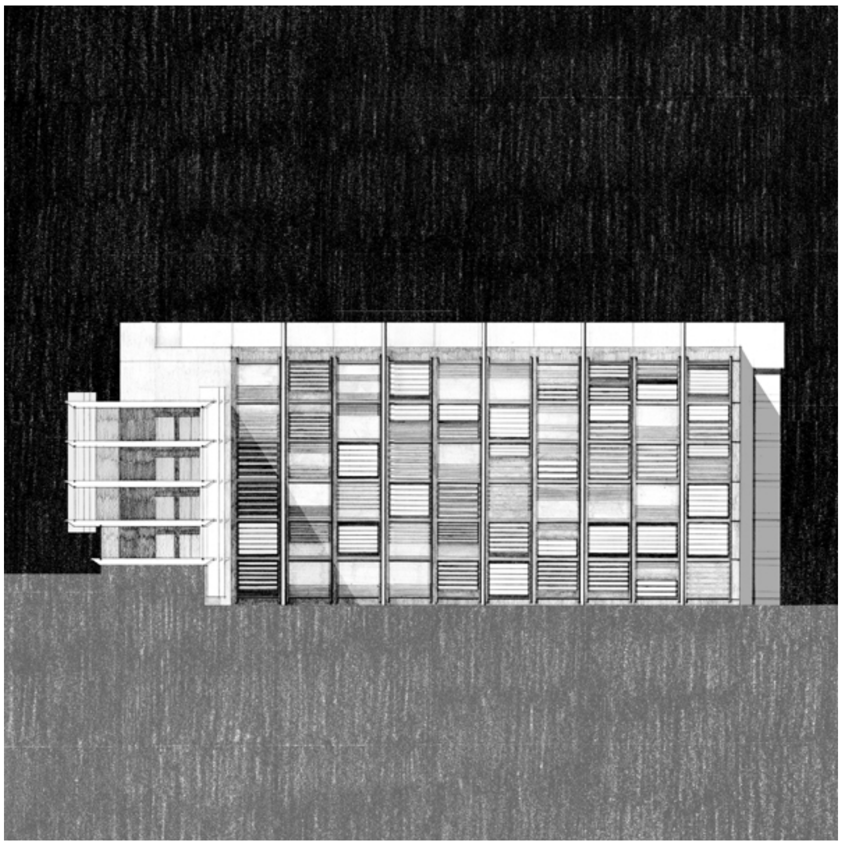

Figure 173. Rear Elevation.

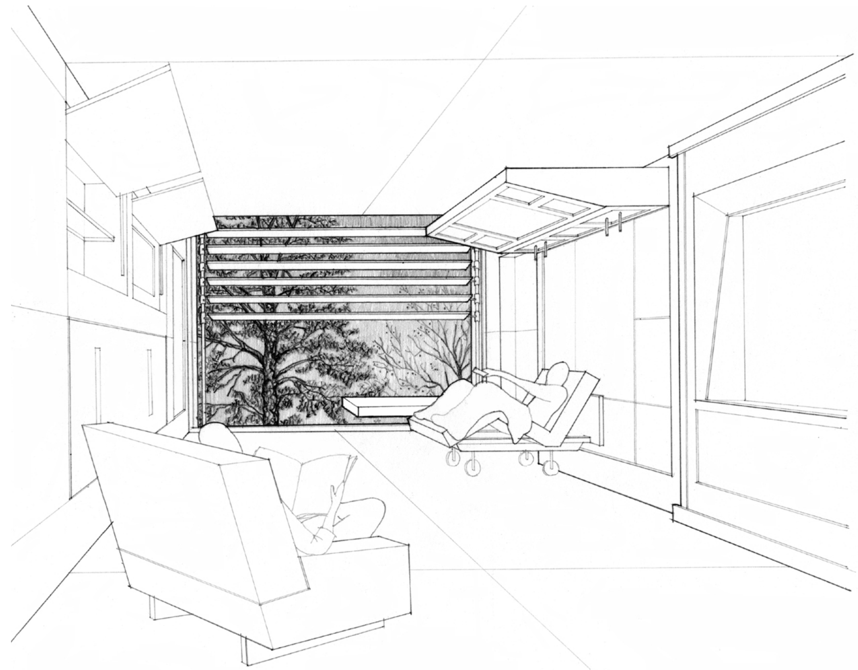

Figure 176. Perspective of Patient Room.

Figure 175. Perspective of Nursing Corridor

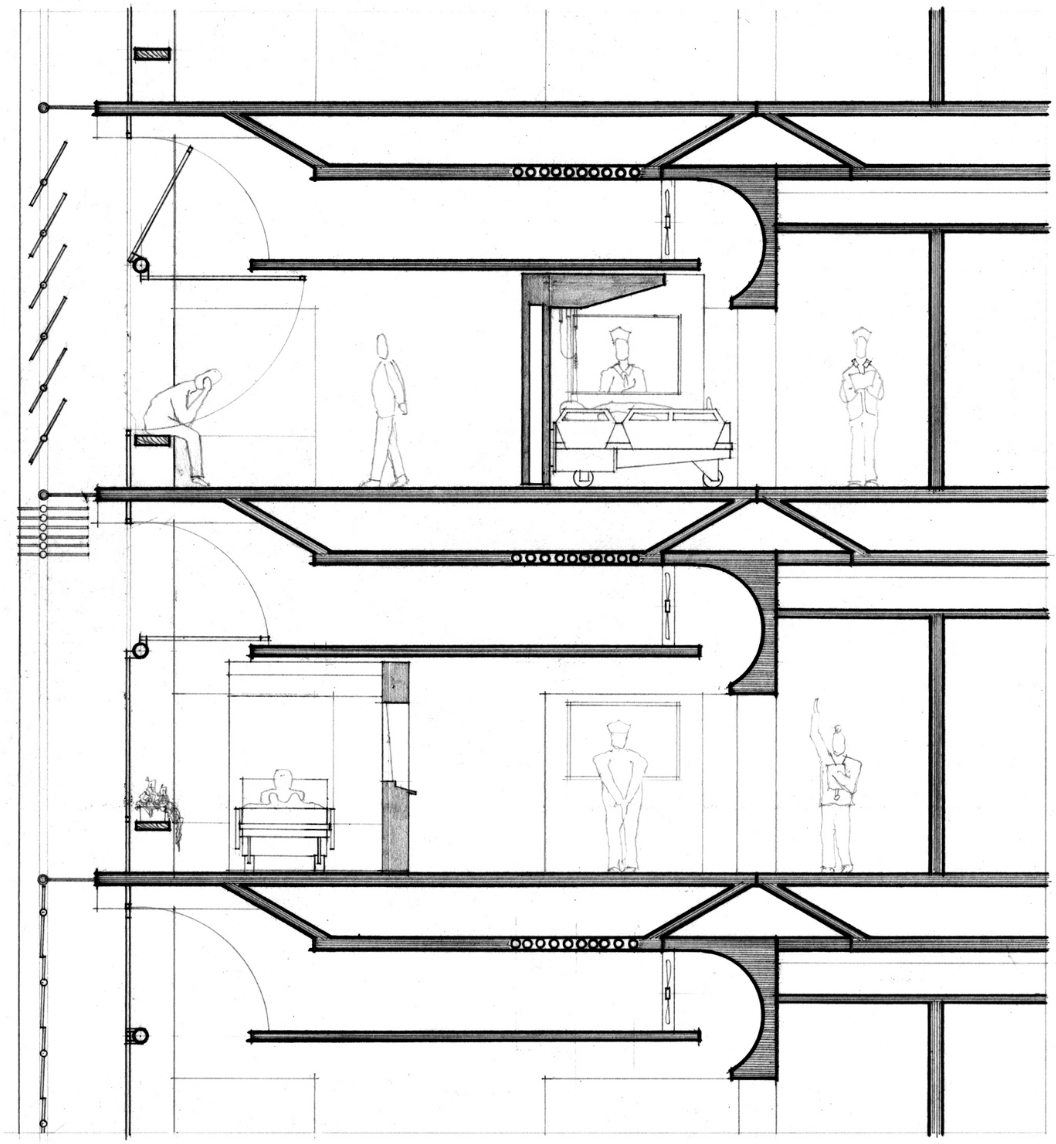

Figure 177. Detail Cross-Section of Patient Unit Wing..

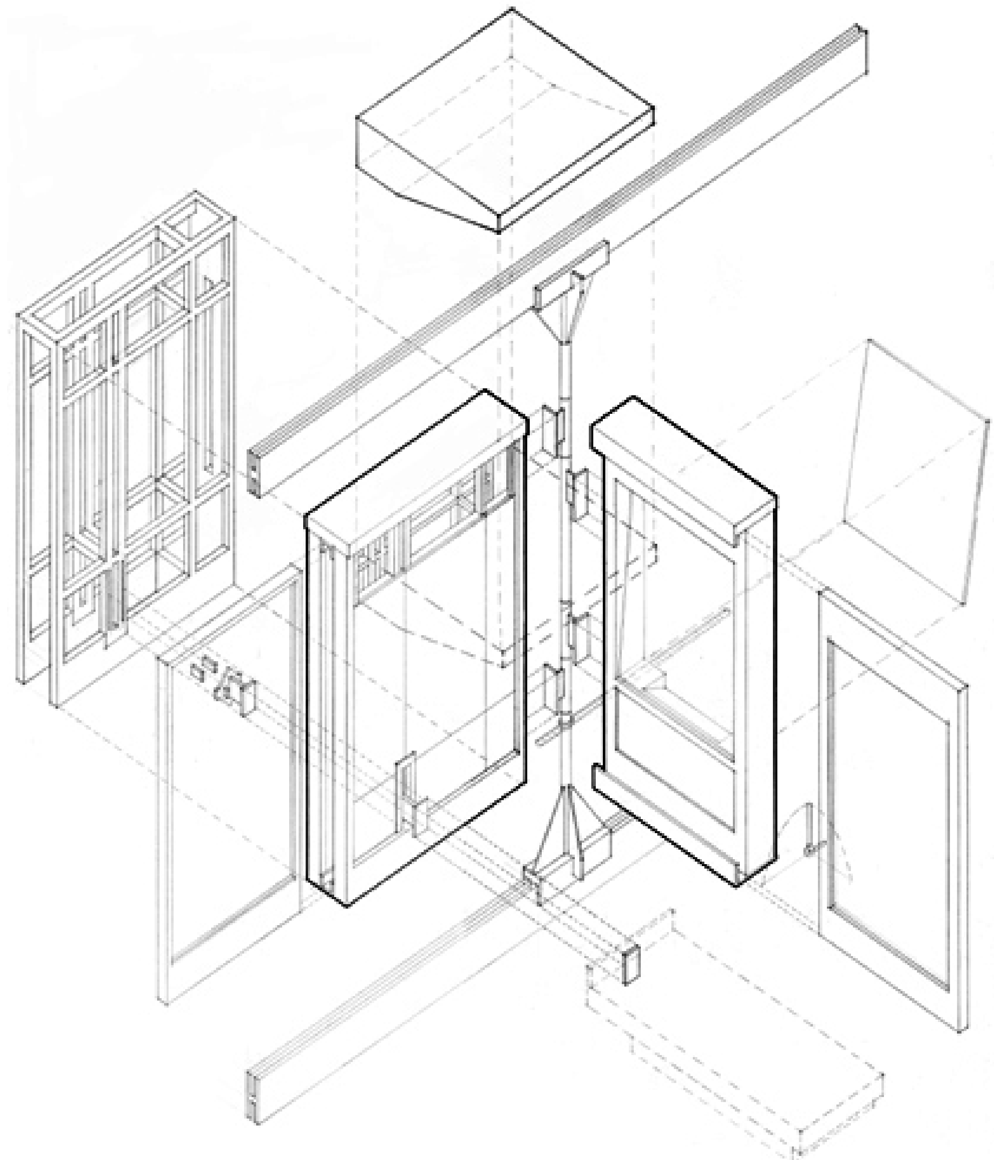

Figure 178. Apparatus Axonometric.

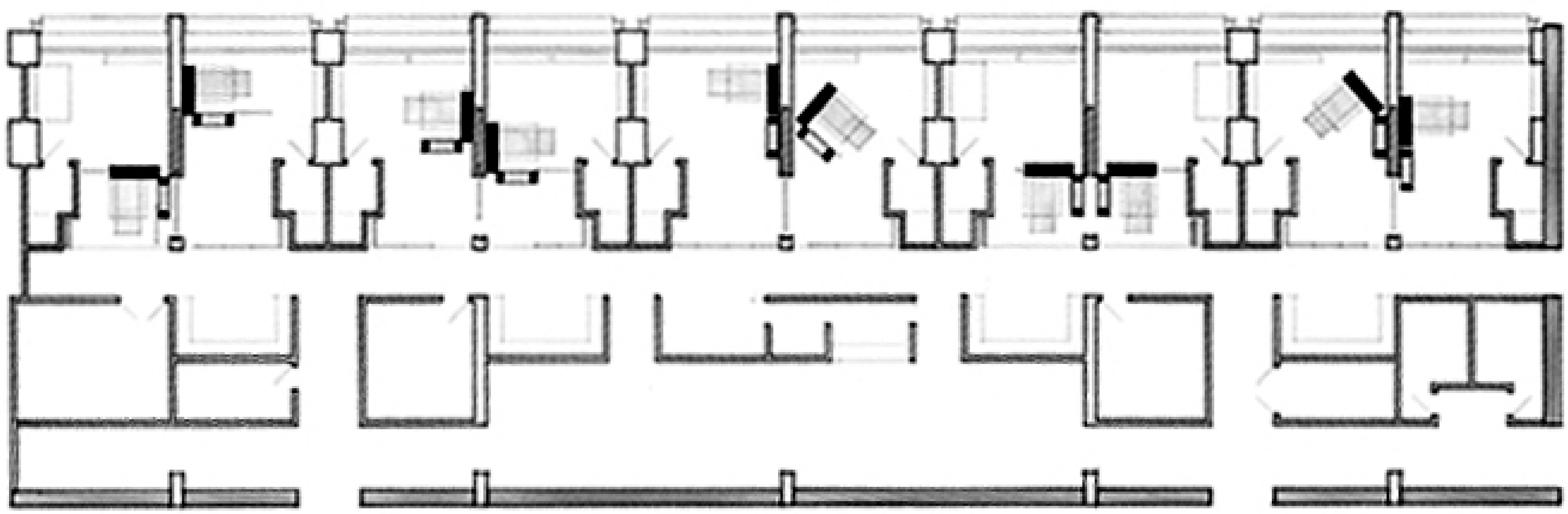

Figure 179. Detailed Plan of Patient Unit.

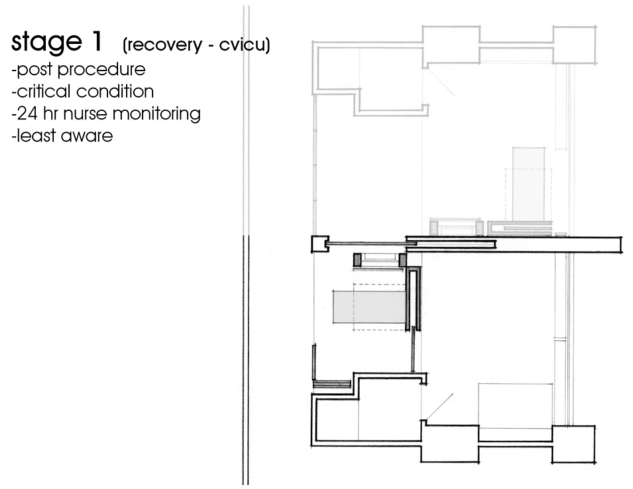

Figure 180. Stage 1 Apparatus Position.

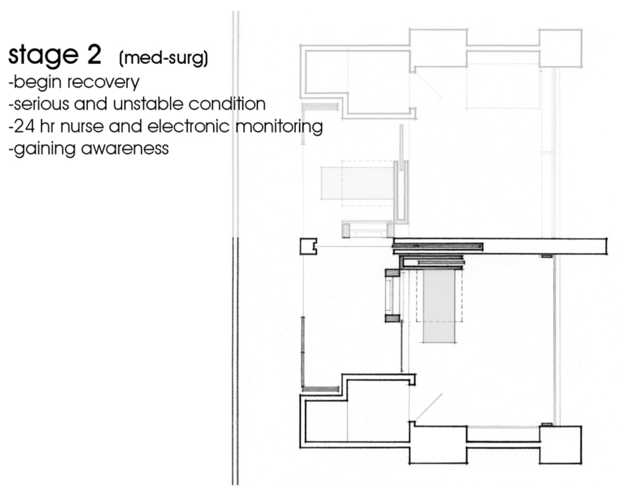

Figure 181. Stage 2 Apparatus Position.

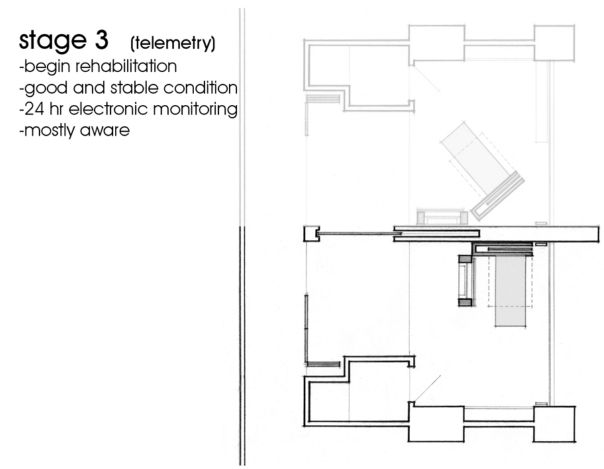

Figure 182. Stage 3 Apparatus Position.

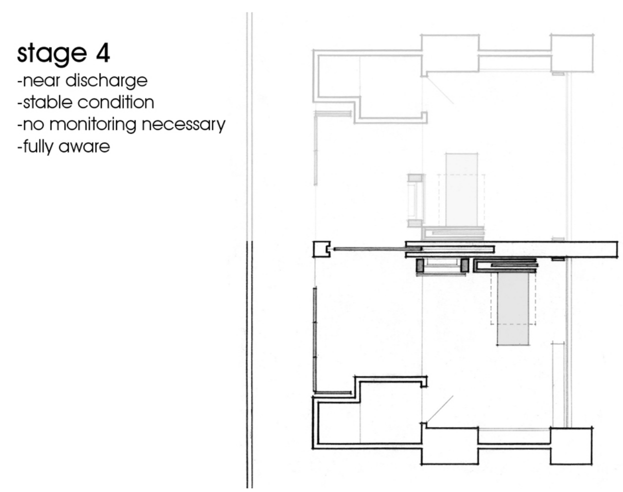

Figure 183. Stage 4 Apparatus Position.

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