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ADAPTIVE CUSTOMIZATION: NEW DESIGN OPPORTUNITIES IN ORTHOPEDICS, DRIVEN BY THE MERGING OF IMAGING AND SURGERY

A thesis presented to the Graduate School of Clemson University in partial fulfillment of the requirements for the professional degree, Master of Architecture.

Marie Oliver McFaddin
May 2007

ABSTRACT

The architectural response for an out-patient orthopedic surgery and rehabilitation facility that merges the fields of imaging and surgery needs to be an architecture of changing needs. Orthopedic patients are a diverse population with varied and changing medical treatment needs. The practice of orthopedic medicine is rapidly changing in response to these needs and ongoing advances in medical technology. One of the most significant changes under way today is the merging of surgical and imaging modalities. Settings for the delivery of orthopedic medicine must be able to better accommodate these changing needs by becoming more easily adaptable while being highly customized at any given point in time.

The architecture of this setting should promote a more efficient, effective and dynamic patient care experience achieved through the use of adaptive customization. Adaptive customization, a form of mass customization, increases the modularity and adaptability of a given product and while providing a greater level of customization to each end user. The design of healthcare settings in general, and settings for the practice of orthopedic surgery in

particular, would benefit from an improved approach to adaptability. This thesis will attempt to demonstrate that it is possible, through the design of healthcare settings that employ principles of adaptive customization, to create a more adaptable environment that can meet the specific needs of many different users and technologies over time.

The design process for this thesis began with a conventional literature review and discussions with experts at leading architectural firms, and multiple site visits to major medical facilities across the country. These interviews and site visits were made possible through an AIA Academy of Architecture for Health Arthur N. Tuttle, Jr. Graduate Fellowship. Interviews were conducted with professionals, ranging from the head of anesthesiology at Massachusetts's General Hospital, to residents in the surgical field at UCLA Medical Center. Shadowing health professionals through operating rooms and observing procedures was an invaluable experience and helped inform this work. Lectures and conferences on related health and architectural topics contributed to the development of a design process and principles centered on the notion of adaptive customization.

Applying adaptive customization to architecture requires developing a prescribed set of design principles. They have been defined to apply at multiple levels of scale and to be applicable as the building changes over time. The building should be conceived as a dynamic physical interface between the contextual or external environment and the programmatic or internal spaces as both conditions change. In order to allow for flexible growth and change over time, co-location of all mechanical, electrical and plumbing utilities is desirable. The co-location of these utilities should also become a distinct design element. The facility should accommodate and celebrate multiple modes of mobility so people with varied disabilities and abilities can freely navigate the building and not feel intimidated or segregated. Adaptive customization must provide a level of user adaptability. The building must be able to be adapted by the facility managers to achieve their desired needs. The building should also accommodate active program elements that are the functional areas of the building and re-active elements that serve the active, functional areas.

An ideal site and setting for testing the implementation of adaptive customization is one that is in a state of change. The proposed thesis project is located as part of the new University of

California - San Francisco campus in the Mission Bay redevelopment area of San Francisco. UCSF has stated a need for orthopedic services as part of the new campus. Because the Mission Bay area and the new UCSF campus will be an area of intense development, the site is and will be in a constant state of change for the foreseeable future. Principles of adaptive customization can therefore also help inform how the thesis project responds to its changing site context over time.

The proposed thesis project consists of an out-patient orthopedic surgery and rehabilitation facility that is programmed for the diagnosis and treatment of multiple musculoskeletal conditions. It is designed to accommodate both the immediate, predicted and unforeseen future needs of orthopedic medical practices. It is also designed to allow for a timeless form of architecture, one that is expected to optimize patient experiences and medical practices over the life of the building. In order to satisfy both current and future programmatic needs, the facility was designed according to principles of adaptive customization. Both the building and site design serve as vehicles to explore the potential of adaptive customization in the design of healthcare settings.

DEDICATION

This thesis is dedicated to my parents because without their love, support, encouragement and prayers this would not have been possible.

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I wish to thank the following individuals and organizations who have made significant contributions to this thesis effort:

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INTRODUCTION: AN ARCHITECTURE OF ADAPTABILITY

With a very high rate of change in healthcare environments, adaptability is paramount. Introducing concepts of adaptive customization in the design of healthcare facilities would allow the physical space to change as a wide variety of healthcare needs evolve over time. Adaptive customization is most applicable to the design of healthcare architecture because it provides a standardized product that the end user can adapt to their changing needs.

For many reasons, there is a great need to minimize disruptions in health care environments during periods of construction. Adaptive customization can reduce these disruptions and allow for a smooth transition during changes in technologies and services. Medical technology is advancing so rapidly it is difficult to design only for the parameters of today, when they will potentially change before the building is even constructed. Thus, implementing a form of adaptability into the architecture itself will allow for better accommodation of these potential constraints.

The merging of medical imaging and surgery affects the architectural environment because the technology associated with these areas of practice is rapidly changing. If the physical environment could more easily adapt to these changes, then there is the potential to improve the quality of service and provide better patient care. Imaging is becoming more interventional and surgery is becoming less invasive. This is resulting in changing medical practices and settings for these services and departments. As technology and practices change, there is a need for the physical environment to respond. In order to do so, there is a need to reconsider the design of healthcare settings in terms of adaptability.

The merging of imaging and surgery and the changes in their practices and technologies affect numerous areas of medicine. This thesis focuses on the specialty of orthopedics where clinical effectiveness, outcomes and the patient experience has been greatly improved as a result of minimally invasive, image guided procedures. The practice of orthopedics is rapidly changing as it has moved from extremely invasive surgery to more delicate, minimally invasive procedures. Rapidly advancing orthopedic medical practices and technologies require a built environment that can adapt and change easily as the technology changes.

Orthopedic patients make up a diverse population with varied healthcare needs and abilities. These needs also require a more flexible and adaptable environment. Emerging trends and technologies in the practice of orthopedic medicine, in addition to higher expectations from orthopedic patients, requires the need for the physical environment to adapt. These changes can be more profoundly achieved through an architectural representation of adaptive customization.

Adaptive customization when appropriately applied to the design of architecture can provide a form of flexibility that can help accommodate the diverse needs and expectations of orthopedic patients. To ensure adaptability throughout the facility, design principles have been established and followed throughout the design process. Likewise, site selection criteria has been developed to help identify and appropriate building and site environment, in which adaptive customization can be pursued to its fullest potential. The Mission Bay area of San

Francisco is rapidly developing and presents both the need and the opportunity to explore adaptive customization through the relationship of the project to its changing site context.

The proposed project for an out-patient orthopedic surgery and rehabilitation facility intends to explore the architectural application of adaptive customization. It seeks to provide a design for the facility that can improve clinical effectiveness and patient outcomes. The design also needs to accommodate change over the life of the structure. This will reduce disruption during periods of change and provide a better user experience through the use of adaptive customization.

THE MERGING OF IMAGING AND SURGERY

The merging of medical imaging and surgery is impacting the design of architectural environments that encompass these modalities. These trends can be accommodated better by providing a more adaptable environment. Imaging is becoming more interventional and surgery is becoming less invasive, resulting in changing medical practices and settings for these services and departments. As technology and practices change, there is an opportunity for the physical environment to respond in a way that creates a more personalized pre-operative, procedure and recovery experience for the patient, family and staff. The architecture needs to easily respond to changes, so the facility can continually accommodate the most current technological trends and provide an improved healthcare process, improved health outcomes and an overall better patient experience.

Technological and Medical Practice Trends

Technological advancements and medical practice trends are rapidly changing and because of this, there is a need for the built environment to change accordingly. Since it is difficult to predict the future of all of technological and medical practice trends, an architecture that can allow for changes to occur would be ideal. It is important to understand the current trends in technology and medical practices in order to design a better built environment.

Technological Trends: Technology is becoming smaller, more sophisticated, more mobile and more universal. Because of this, the healthcare environment should accommodate these advancing technologies. These emerging technologies range from surgical robotics to mobile medical equipment and all have implications on the design of the physical environment.

Surgical robotics allows for greater precision, miniaturization and advanced articulation beyond the capabilities of normal human manipulation. They are used as tools to extend the surgical skills of a trained surgeon. Some of these robotic technologies will require more physical space within the surgical setting. Others robots are becoming smaller and more mobile and will need less space.

Fig. 1 Da Vinci at UCLA Medical Center

The Da Vinci Robot currently requires a great deal of physical space within the operating room. The system consists of a large surgeon's console, a patient-side cart with four interactive robotic arms and multiple monitors for viewing. The Da Vinci is powered by the surgeon's hand movements, which are then scaled, filtered and seamlessly translated into precise movements of the robotic arms and instruments. It was used in at least 16,000 surgical cases in the United States in 2006. (Intuitive Surgical, 3) Currently, most hospitals that invest in the Da Vinci are either required to build a dedicated OR or enlarge an existing operating room to accommodate for all necessary equipment. This results in oversized operating rooms that go unused when the Da Vinci is not needed. (Sandberg, 2006) This is valuable square footage that could be designated to other uses. If the architectural environment could adapt to accommodate for the Da Vinci when needed and then change to adapt for other uses as well, it would maximize the use of the operating room.

Fig. 2 RoboDoc

Currently, the Da Vinci is the only Robot that is being used in the United States, however many others have been implemented into surgical settings in other countries. Having an understanding of these new robots, will help shed light on what the future of robotic in the United States may resemble.

Fig.3 Equipment in the Corridor – Massachusetts's General Hospital

In 1992, the RoboDoc Surgical System was unveiled and is currently being used in Germany, Austria, Spain, France, England, Switzerland, the Middle East, Japan, Korea and India. The RoboDoc uses computer tomography to obtain structural information of the surgical patient pre-operatively and is then used to cut the patient's bones precisely. It is used in total hip replacements and total knee replacements. Cases involving RoboDoc result in one-third less hospital recovery time for patients. (www.robodoc.com) It also substantially decreases the time needed in the operating room. The RoboDoc resembles a drill press and while requiring a large amount of physical space, it is mobile. It affects the physical environment because if the equipment is not planned for, then it ends up in corridors and even just sitting, when unused, in the operating room. This causes a potentially unsafe environment that does not meet required code regulations. The built environment could accommodate this equipment in a more desirable way, such as providing areas outside operating rooms that are designated for mobile equipment.

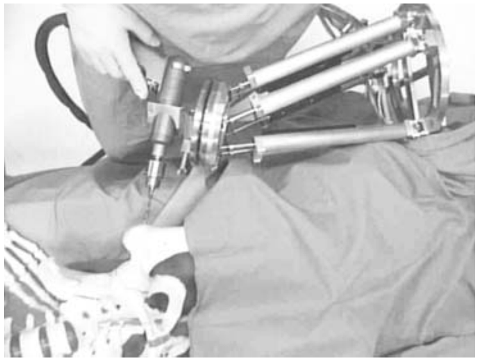


Fig. 4 CRIGOS

In contrast to the larger robots, the CRIGOS or Compact Robot system for Image-Guided Orthopedic Surgery is very small. It is also a more cost-effective robot. Prototypes are currently being developed to be used in computer-assisted surgery. (Brandt, 7) The advantage of the CRIGOS is that because they are so small, portable and disposable they have little effect on the built environment. This allows more flexibility of the architectural setting. As robots advance and are implemented more into the surgical setting, they will need the built environment to be able to respond to their changing needs.

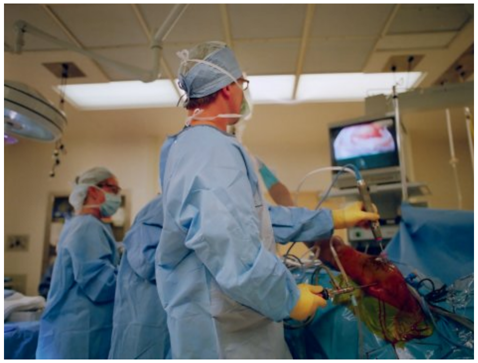


Fig. 5 Shoulder Arthroscopy

Arthroscopy, another technological trend, allows for more minimally invasive procedures that reduce patient's procedure and recovery times. This results in more out-patient procedures and an increase in the rate of surgical success. Arthroscopy employs small thin endoscopes to view and perform detailed surgery. A keyhole incision is made in the skin and the arthroscope can shave, cut or remove tissue or bone that is causing problems. It was originally pioneered to perform minimally invasive cartilage surgery and re-construction of torn ligaments. It is predicted by 2010 that arthroscopy will account for $2 billion of the United States healthcare market and this will have a dramatic affect on the number of out-patient procedures that can be performed. (Kyes, 2) It is advantageous because it requires a minimal amount of equipment and can be used in most traditional ORs as well as smaller interventional settings.

Another technological trend is the decreased use of analog based systems in operating rooms, as most medical facilities have entered the digital age. Old analog based systems are typically linked to the specific equipment within each room. For example, image intensifiers were sized for each individual room. However, with a digitally equipped room a wider variety of procedure types can be accommodated. (Rostenberg, 2005) This allows one room to be used for a variety of procedures, so it can adapt to multiple surgery types on a daily basis improving room utilization.

Imaging technologies have advanced and now allow image data to be received in minutes rather than hours, greatly reducing diagnostic and treatment times. This also makes it possible to perform both diagnosis and treatment in the same patient visit. Typically a patient would be required to come for a diagnostic appointment to assess the problem and then return at a later date for a procedure to correct the problem. This was due to the fact that it took longer to acquire an image, access it and interpret it with film based media. Then the radiologist had to dictate and send a hard copy of the report and film to the surgeon and or lead physician. Now, with the advances such as, high speed computed tomography angiography (CTA), magnetic resonance angiography (MRA), mobile CT scans and advances in the MRI, data can be received in a very short amount of time. Thus making it possible to diagnosis a patient and perform the needed procedure in the same visit. This has an impact on the patient's medical process and requires the built environment to be able to accommodate both diagnosis and treatment in the same setting.

Another medical technology trend is the utilization of the Orthone MRI. The Orthone MRI is smaller and less physically restricted than a typical large bore MRI. It is a comfortable, non-


Fig. 6 Orthone MRI, Stone Clinic,
San Francisco

threatening, non-claustrophobic MRI device that creates scans with extremely high quality images. It is an open MRI system where the scans are dedicated to extremities and performed while sitting in a comfortable chair. It provides a very different MRI experience than a full body scan. The Orthone MRI unit was originally designed in Italy and currently very few exist in the United States. (Kwolyk, 1) It is intended to be all inclusive and freestanding. The copper shielding required for all MRIs is within its cylindrical enclosure and it can be placed in any built environment. This is extremely advantageous to the architectural setting because it does not require more permanent RF or magnetic shielding. In that way, the Orthone MRI is portable and more easily positioned and relocated when needs change within a facility.

There has been an increase in the use of the technology of laser (light amplification by stimulated emission of radiation) systems. Lasers allow surgeons to accomplish more complex tasks, control bleeding, decrease post-operative discomfort, reduce the chance of infection and result in better wound healing. They have the ability to cut, vaporize or coagulate using the same laser. It can also cut or destroy tissue that is abnormal or diseased without harming healthy, normal tissue. Laser systems are extremely portable, making it easier to serve more patient rooms with the same technology. This means there is no need to design specifically for these systems within the built environment because they are so transportable.

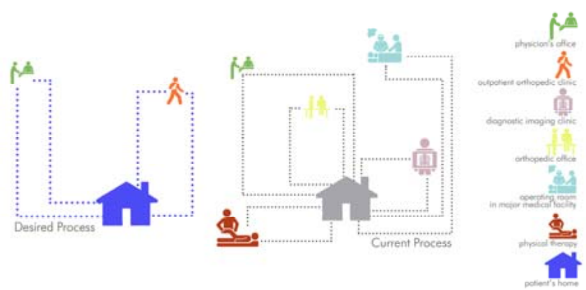


Fig. 7 Diagram of Desired Medical Process

Trends in Medical Practice: These new and advancing technologies have changed the way in which care is delivered. The patient's medical process, from injury to recovery, is becoming more streamlined and efficient, resulting in more out-patient procedures and faster patient turnaround. More out-patient procedures will require the need to re-think the necessity for large major medical centers and to re-think the appropriate size of out-patient facilities.

Out-patient surgery increased from 16 percent of all hospital surgeries in 1980 to 44 percent in 1987 and by 1993 the majority of surgeries performed by hospitals took place in out-patient settings. (Duffy, 1) There are also more financial incentives for out-patient procedures as opposed to in-patient from a facilities perspective because it is expensive to maintain operations 24 hours a day. (Health Care Intelligence, 2006) As the number of out-patient procedures increase, out-patient facilities will need to increase in size to accommodate this medical practice trend.

Limited service hospitals are “niche” hospitals. They typically include heart hospitals, orthopedic hospitals, surgical hospitals and ambulatory hospitals, imaging centers and a large number of other narrowly-focused providers. The trend in the rise of limited service hospitals is resulting in the decentralization of major medical centers to smaller more specialized facilities. Surgical facilities represent the largest number of limited-service facilities and orthopedic facilities represent the second largest number of limited-service facilities. (2005 AHA Survey of Hospital Leaders) The increase in the number of limited service hospitals gives the designer the ability to focus on a more specific patient population and design a better experience for a more defined and homogeneous group of users, both patients and care providers.

Trends in Medical Imaging and Surgery: The imaging process is becoming more interventional as imaging procedures are used to treat patients as well as provide clinical information. The field of medical imaging is no longer limited to diagnostic procedures. This means that a physical aliment can be viewed, assessed and treated all in the same patient visit because of advances in real time imaging devices. This requires a new physical environment that can accommodate both imaging and interventional equipment and activities.

When imaging modalities are used in the surgical setting the anatomy is viewed indirectly through a video system by viewing images displayed on a monitor rather than by only looking at the surgical site directly. This requires the need to assess the ergonomics and lighting constraints of the monitors. Placement of the monitors is also dependent on the type of surgery being performed and who is using the images. (Rostenberg, 363) The placements of these monitors is dependent upon which portion of the body the procedure is being performed on, if it is the left or right side of the body the monitors will need to be moveable to adapt. As monitors have decreased in size, it is easier to accommodate for a variety of positions within the same room. Other larger imaging equipment used in interventional procedures has become more mobile. If this additional equipment is not fixed, then the room can be used for a variety of imaging and interventional procedures.

Fig. 8 Imaging Modalities in Surgical Suite

Imaging in the surgical setting, results in more minimally invasive procedures as surgeons use arthroscopy and other technologies to view the anatomy through small probes. Thus, surgery is becoming less invasive as image guided procedures are increasingly more common. Using image guidance during procedures allows surgeons to better visualize relevant physical data and gives real time feedback to surgeons. Some of the imaging modalities being used in the operating room are ultrasound, virtual or augmented reality, computed tomography and portable radiography and fluoroscopy. (Rostenberg, 367) The architectural environment will need to adapt to accommodate for these new modalities by being as flexible as possible.

Physical space for imaging equipment will be required within an operating room environment. This imaging equipment is either ceiling mounted on a track system or is mobile. If the equipment is ceiling mounted it will require coordination with all monitors and the windows to technician observation areas. If the equipment is mobile it can be stored outside the operating room in assigned closet or alcove space for use by multiple rooms.

Many of these medical imaging techniques used in surgery are in constant flux, due in part to the continuous development of new medical technologies. This results in the facility requirements changing rapidly and frequently. (Rostenberg, 362) Specific design solutions must accommodate current technology, while more general long-range design strategies should anticipate the impact of future technologies.

Implications on Healthcare Services and Settings

There will be changes in the practices and settings for the services and departments that react to medical imaging becoming more interventional and surgery becoming less invasive. Changes to the relationships between the imaging and surgery departments will create a new department that is not designated specifically as imaging or as surgery, but can accommodate both. These changes between the relationships of the departments will also result in the reduction of the duplication of rooms, equipment, staff and activities. As both departments begin more and more to need access to the same patients and information, a closer physical relationship of these two departments may become necessary. This will also result in some shared spaces as the departments become more similar and new staffing positions, such as surgical technologists and surgical information technologists will emerge. (Rostenberg, 49)

The changes in the practices and settings within each department will result in a need for a reconfiguration of the departmental and procedure room layout. More stringent flow control

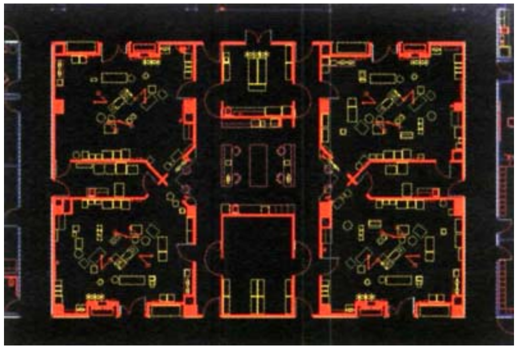


Fig. 9 Cluster of Procedure Rooms

for imaging suites and more lenient rules for configuring surgical suites will result in new layouts applicable to both. One such example is a hypothetical layout for a cluster of procedure rooms. This layout would provide a staff core that contains imaging control alcoves and supply zones. (Rostenberg, 49) This differs from a traditional clean core in that this core is designed for observation into the procedure rooms as well. Observation areas are needed in imaging suites. So in that regard, this new cluster of procedure rooms is a combination between a surgical suite and an imaging suite.

These changes will result in the merging of the imaging and surgery departments, as they begin to use more of the same physical spaces. The departments can become even more integrated as room adjacencies are no longer affected by the flow of information. The information can travel faster and further because imaging information now flows through cables, not corridors, which results in a greater need for electrical, mechanical and data infrastructure. (Stein, 4) This need will differ depending on the size of the facility. But allowing enough physical space to manage all required cables will allow for future growth and any potential changes in technology. Co-location and merging of the departments are possible as the technologies become more similar and more advanced.

Diagnostic and treatment spaces will change because now they can be performed in the same physical environment. These procedure rooms are a combination between an operating room and an imaging suite. Some of these rooms exist today, such as, Cath Labs and Interventional suites. However, these rooms can be extremely oversized, sometimes as large as 800 square feet. (OR Manager, 2) This is mostly to accommodate for all required equipment and provide enough space for changes in the technology. However, based on the research of technological trends, they seem to be becoming smaller and more mobile and this would not necessarily require more physical space.

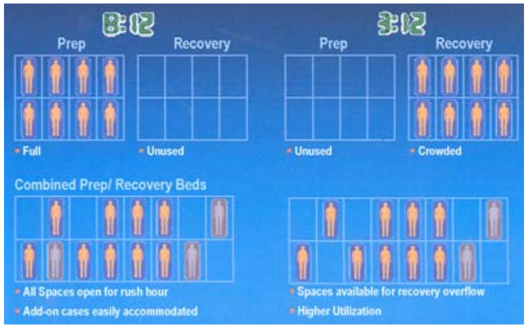


Fig. 10 Patterns of Utilization Diagram for Pre-op and Recovery Spaces

Changes in pre-op and recovery spaces will occur because a more universal procedure room will allow for a more centralized pre-op and recovery area. If one room can serve a variety of procedures, then the pre-op and recovery space associated with those rooms can be co-located as well. Typically more decentralized pre-op and recovery spaces have issues of over-crowding in the pre-op in the morning and then over-crowding in recovery in the evening. If they are more centrally located, and pre-op space and recovery areas can be more closely located, then they can utilize one another when needed. This will assist in the fluctuation of prep or pre-operation spaces during morning hours to more recovery spaces later in the afternoon. This will also assist in more easily accommodating add-on surgical cases because you can use a recovery room as a pre-op room if need be. This will all result in a higher overall utilization of the pre-op and recovery areas and a potential reduction in unnecessary duplication of these spaces.

Improving the Healthcare Process: As technology and medical practices change, there is an opportunity for the physical environment to respond. This response should create a more personalized pre-operation, procedure and post-operation experience for the patient, family and staff while improving both the health process and outcomes. The current healthcare process for patients and staff can be frightening and perplexing. It usually takes place in large medical facilities and requires patients to be transferred to multiple departments.

Fig. 11 Current pre-op, procedure and recovery experience

The process observed at Brigham and Women's Hospital, Massachusetts's General Hospital and UCLA Medical Center was confusing and overwhelming. They are all large and intimidating facilities. In part, this is due to their sheer volume. It is hard to navigate such a large facility. At the site level each has legible way-finding devises that makes entry into the facility relatively easy. Brigham and Women's Hospital implements "the Pike" as a way-finding device within the hospital itself, which is helpful. But, once a patient or visitor travels beyond these areas, things can get confusing very quickly. The pre-op and recovery areas of each facility were crowded, loud and provided little to no privacy for patients. Families had no appropriate place to be with their loved ones and often these spaces provided no sense of orientation, with no exterior views. Patients were then transferred to their procedure and often returned to recovery areas in a different part of the hospital. This puts the patient in another strange environment and requires the family to navigate their way to another area as well. It seems from observation that there is a great opportunity to improve the medical process for the patients, family and staff.

Placing the modalities of imaging and surgery within the same room allows for the co-location of pre-op and recovery areas which can help improve the healthcare process. It allows for a more convenient patient experience, rather than having patients travel to multiple areas of the hospital or multiple rooms. This would reduce the travel distance for staff, which would allow them to spend more time on personalized patient care as opposed to moving from place to place. It would also allow patient's families to stay in one location, providing a more relaxing, less stressful experience for all involved. How does it impact the need for change – does this universal approach allow for change in use without physical change?

Improving Health Outcomes: Improved health outcomes can be achieved through the advances in medical technologies and the medical practices that response to these technologies. These improvements can help reduce areas of concern to individuals and patients, such as, the need to reduce medical errors, hospital acquired infections and surgical complications. Medical errors can be reduced by making changes to the physical environment that reduce travel distances. Errors occur during patient transfers, so minimizing transfers can improve the continuity of care and minimize opportunities for miscommunication of critical patient information during handoff. Minimizing transfers and facilitating the effective transfer of care, when necessary, can be improved through the co-location of pre-op and recovery and a shorter travel distance to procedure rooms.

It has also been proven that the closer in proximity the patient is to the caregiver and to medical data the more medical errors can be reduced. (www.mercurymd.com) In a comprehensive study of admissions to eleven units in two tertiary care hospitals over six months, 334 medical errors were identified. It was found that proximity of data, patient and the provider had an impact on some of these errors. Twenty-two percent of the errors were caused by inadequate knowledge of the medication, and another fourteen percent of the errors resulted from inadequate knowledge of the patient. (Leape 1995) The closer the patients are to the caregiver and the data, the more medical errors can be reduced and by doing so, provide more responsible care for patients and a less stressful environment for staff.

Minimally invasive procedures can help minimize hospital acquired infections because they utilize more disposable supplies and catheters. Medical and surgical devices may serve as vehicles for infection. Even though all hospitals should have a comprehensive disinfection and sterilization policies, it is a variable in which supplies could become contaminated. According to the Manual of Infection Control Procedures, the suggested method for numerous supplies and catheters is a single-use disposable. (Damani, 80) Disposable supplies reduce the chance of infection because there is no need for the unpredictability of the disinfection process. It is because of this and other new technologies that a more relaxed protocol on infection control is becoming possible. This provides the opportunity to re-think the need for a clean-core layout which is designated solely to house clean supplies after sterilization. Instead, it allows the core not only to be used to house supplies needed for surgery, but also to serve as work spaces. This could be achieved without compromising infection control because prepackaged supplies would be only be opened in the procedure room itself.

Minimally invasive procedures reduce the incision size on a patient, thus helping to minimize surgical complications sometimes associated with open surgery. Minimally invasive surgery is becoming mandatory for some surgical procedures because it reduces surgical complications and can improve the patient's post-procedure quality of life. It can be performed under local or regional anesthesia, requiring only sedation, which results in less side effects and post-operative pain compared to traditional general anesthesia. These procedures can also causes significantly less less damage to tissue, a reduced recovery time, faster return to normal activities and less scarring.

There is a need for the built environment to accommodate for minimally invasive procedures because they provide so many improved outcomes for patients. Minimally invasive procedures are performed in surgical environments that include both imaging and surgery equipment. The facility needs to be able to accommodate for these technologies as they exist today, but also be able to adapt as the needs of these procedures and technologies change overtime.


Fig. 12 More Relaxed Patient Experience

Improving the Patient Experience: Changes in medical technologies and practices now make it possible to provide universal rooms for pre-op, procedure and recovery. This should result in an improvement in the overall patient experience. It should provide a more convenient patient process, rather than having patients travel to multiple sites or multiple rooms. Patients will receive care in a more timely manner because diagnosis and treatment can occur in the same location and can be done simultaneously. This would also be an environment where surgeons, radiologists and technicians could work integrally and where various types of equipment can be shared, rather than duplicated. A more universal procedure rooms will help consolidate the physical space a patient needs to negotiate, creating a more streamlined medical experience. This will also allow the designer to have a greater impact on the patient experience, since the process is simplified.

Even on an out-patient basis, the unfamiliarity of the medical setting, loss of privacy and detachment from friends and loved ones can add unnecessary stress to a patient. The physical environment should be designed to help eliminate these concerns and provide a

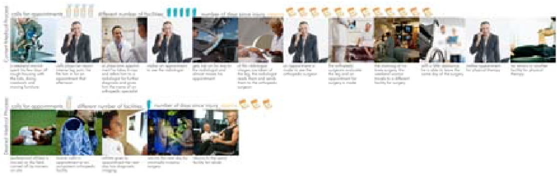


Fig. 13 Desired Medical Process, Reduced Recovery Time

better patient experience. Providing private, holistic rooms within minimally invasive surgical settings it can benefit the patient on multiple levels. This new setting where diagnostic, treatment and patient care are combined allows for a greater level of adaptability within the room and the facility as a whole. This will result in a more relaxed patient experience and improve the medical process and outcomes.

The Need for Adaptable Environments: It is relatively apparent that in order for the built environment to adequately respond to these trends, it needs to provide for a greater level of adaptability. When responding to varying technologies, such as robotics, arthroscopy, and lasers, the built environment has to change in different ways to respond to each and will continue to change as technologies continue to emerge and evolve. Some technologies required larger rooms and some could be accommodated in smaller spaces. Some make a more universal room possible. Others technologies need to be ceiling mounted and still others rely little on the built environment at all. So, it is hard to predict how changes will occur and it would be most advantageous if the built environment could quickly and easily adapt in an open an highly flexible way to accommodate the unknown future demands and constraints of ever changing technologies.

The trends in medical practices are requiring a more adaptable built environment as well. Facilities will need to change as trends shift from the two distinct departments of imaging and surgery to more universal procedure rooms. As more universal rooms emerge, post-op and recovery spaces can also become co-located. As infection control issues become less stringent, the built environment can adapt. Many medical practices will change as technology transforms and because there are so many unknowns it is most desirable for the built environment to be easily adaptable.

Healthcare architecture should focus on being able to react to these changing needs of technologies and medical practices, as well as, the changing needs of those who receive care. The patient population of orthopedic medicine has a broad range of needs and the technologies in the field of orthopedics are rapidly changing as well.

ORTHOPEDIC MEDICINE AND ARCHITECTURE

The merging of imaging and surgery and the changes in their practices and technologies affect numerous areas of medicine. Neurology, oncology and cardiology patients will benefit from image guided procedures that provide improved medical outcomes. However, it may have little effect on their patient experience because they are usually sedated during the procedure portion of their medical process. Orthopedic patients are commonly more conscience and given only local or light anesthesia during most minimally invasive out-patient procedures. This means that the experiential quality of the orthopedic patient's entire medical process is more likely to be remembered and have an impact on their perception of the quality of care. Thus, there is the opportunity and the architectural response to the emerging trends and technologies mentioned in the previous chapter to have more of an impact on orthopedic patients. It is therefore within the specialty of orthopedics that the impact of clinical effectiveness, outcomes as well as the patient experience will be examined in this thesis with respect to accommodating the aforementioned forces of change.

The architectural environment should respond to the varied healthcare needs of the diverse population of orthopedic patients. These assorted needs can be addressed by providing a built environment that offers forms of customization to the patients. At the same time, rapidly advancing orthopedic medical practices and technologies require a built environment that can adapt and change easily. A balance between addressing the customized yet varied needs of patient's today with the changing needs of medical practice and technologies in orthopedic medicine could be better achieved with a flexible and adaptable environment.

Practices and Patients

Orthopedic patients and the medical practice of orthopedics have changed as technological advances have allowed for more minimally invasive surgery and more out-patient procedures. These changes affect the patient and staff needs significantly, in some of the following ways. Orthopedic patients no longer have to travel to multiple facilities to receive diagnosis and treatment of musculoskeletal conditions. This results in faster recovery times. They are also typically under local anesthesia and are more aware of their surroundings during a procedure. This makes the patient's experiential process throughout their entire medical progression more significant. To adequately respond to patient's needs, those who care for orthopedic patients may now need to acquire images of the patient's limbs, read the images, perform or assist in the treatment procedure and assist in the rehabilitation of the patient - all within the same facility.

These changes have an impact on the physical environment because more tasks are being performed in one location. This allows consolidation of the physical space in which they occur. However, not knowing the future changes in the practices and technologies of orthopedics, the physical environment will need to continuously adapt. It should respond to these technological needs with minimal disruptions to patient care. It should also be able to respond to the diverse patient population of orthopedics and provide a more customized patient experience.

In order to design architecture for orthopedic medicine that is more customizable and adaptable it is important to better understand orthopedic medicine and the patient population. Orthopedic medicine is devoted to the study, diagnosis, and treatment of the skeletal system, including its joints, muscles, tendons and associated structures. More than 8 million people were hospitalized in 2003 for musculoskeletal conditions. These conditions were also the cause for 56 percent of all physician visits throughout the United States. Each year U.S. children miss approximately 21 million days of school due to musculoskeletal injuries and employees miss more than 147 million work days. (Medical Reporter, 2006) As arthritis remains the leading chronic condition among the nation's rapidly growing group of elders, orthopedic surgery spans multiple generations. With one in seven Americans suffering from a muscular impairment, orthopedics is an area with great potential to impact a large and diverse group of patients.

Because the area of orthopedics affects such a significant patient population, much effort and research has been invested into advancing and improving the quality of the procedures these patients require. These treatments currently occur either in large medical facilities or specialty facilities that focus specifically on one area of orthopedics, such as sports medicine.

Technology now provides the opportunity to offer quality orthopedic care in out-patient settings and treat multiple forms of musculoskeletal conditions in the same facility. Even so, many surgeons still perform their procedures in a hospital setting. For example, The Stone Clinic in San Francisco offers full service orthopedic care. A patient can go to the facility for diagnosis and rehabilitation, but when the actual procedure needs to occur, the surgeon books time in a major medical facility and performs the procedure there. There are advantages to both patients and physicians if the procedures could be performed within one facility. These advantages include faster care, convenience and a more relaxed patient process. The technology has advanced and has given the architectural environment the opportunity to accommodate more surgical procedures in an out-patient setting.

Changes in Orthopedic Practice: The most significant change in the practice of orthopedic medicine is the move toward more minimally invasive surgeries. This is evident when reviewing the top ten most common orthopedic surgeries performed in the United States. They are as follows:

1_Knee arthroscopy and menisectomy

2_Shoulder arthroscopy and decompression

3_Carpal tunnel release

4_Knee arthroscopy and chondroplasty

5_Removal of support implant

6_Knee arthroscopy and anterior cruciate ligament reconstruction

7_Knee replacement

8_Repair of femoral neck fracture

9_Repair of trochanteric fracture

10_Debridement of skin/muscle/bone/fracture

All of the most common orthopedic surgery procedures can be performed through a form of minimally invasive surgery, meaning an incision of 3-4 inches or less. And, at least six of these top ten surgeries, including shoulder and knee arthroscopy, carpal tunnel release, knee chondroplasy, repair of trochanteric and debridement of skin, muscle, or bone fractures, can be performed as an out-patient procedure, through minimally invasive, image or visualization guided surgery. This move toward minimally invasive procedures has resulted in better patient treatment and care. These changes create the ability to diagnosis and treat orthopedic patients in one out-patient care setting.

Because one care setting for all of orthopedics is possible, these facilities should be able to be customized to satisfy the needs of varying degrees of patients. Co-location of all orthopedic care is desirable because the facility will attract higher quality medical professionals which will benefit patients. However, orthopedic patients have varied needs and expectations and if they are all treated in the same facility, then the facility will have to be customizable to meet the needs of the entire orthopedic patient population.

Changing Patient Demographics: Orthopedic patients range from Olympians to those suffering from arthritis. They are typically physically restricted in some way, have limited mobility and a limited range of motion. They also have varied treatment needs and medical experience expectations. These varied needs require a more adaptable physical environment in order to meet their physical needs, without compromising their overall patient experience. For the purposes of delineation within this body of work and to later reference patient's expectations, the extent of orthopedic patients have been identified into four distinct categories. These categories are professional athletes and Olympians, amateur athletes, weekend warriors and patients with arthritis. Each distinct patient population has a variety of needs and expectation of their medical experience and the quality of care they are provided.

One of the most significant things to note about orthopedic patients is they are typically accustomed to being healthy. They will find their injury a nuisance or hindrance to their

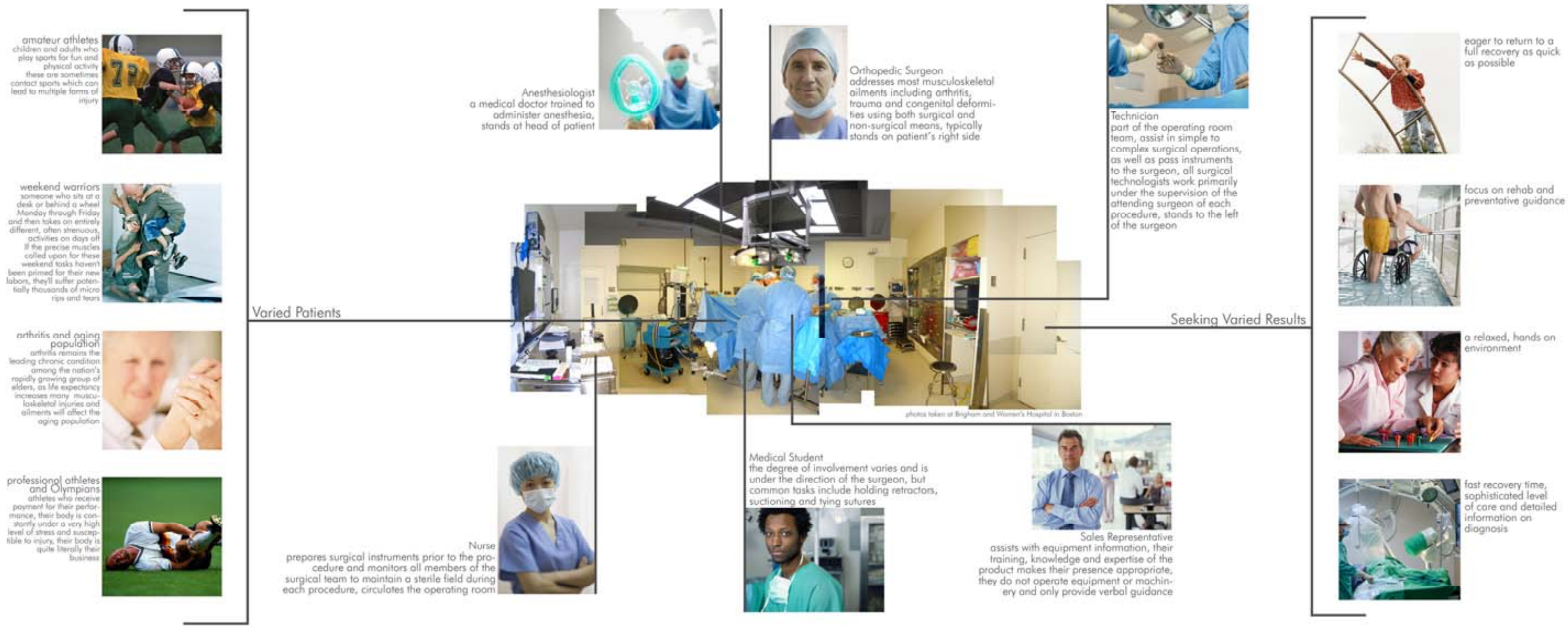


Fig. 14 Varied Patients and Expectations

normal routine. If a more adaptable medical environment is designed for them, it will make their recovery process less stressful by catering to their individual needs.

Higher Patient Expectations of Medical Experience: With the advent of the internet and other available services, consumers and patients have become more knowledgeable about their bodies and the medical advances available to them. If a facility is able to offer the latest technological advances, it has the potential to increase their volume of patients. Therefore, these facilities must be designed to rapidly adapt to the changing demands and opportunities of new technologies and practices. This can be achieved by providing the infrastructure that can allow for multiple technologies and the unknown technologies of the future.

Even though patients have a greater knowledge of medical advances, it is the experience of those technologies with which they connect. The experiential quality of the medical encounter has a great impact on a patient, sometimes more so than even the treatment itself. Marshall McLuhan, author of *The Medium is the Message*, said "Everybody experiences far more than they understand, yet it is the experience rather than the understanding that influences behavior." (Meyrowitz, 13) This is particularly true of medical experiences. It is not as important that a patient fully understand the technology, but that the experience is understandable, relatable, faster, less painful, less stressful and maybe even enjoyable.

Since the patient experience is important, the facility needs to place an emphasis on providing a quality experience to their patients, not just quality care. If the facility can provide a more customized experience to the patients, then they will be more satisfied. This can be achieved by providing options for patients at multiple levels of their medical process. These options, or opportunities to customize their experience, can help allow the medical environment to meet more of their expectations.

Fig. 15 NikeTown

This need or desire for a positive patient experience has resulted in the emergence of the "experience economy". (Pine, 29) This is not just offering a better consumer experience, but providing a more defined experience that translates to economic gains for the facility. Disney has offered an experience with a price for years, but this concept is translating beyond theatres and theme parks and into all other forms of business. Starbucks, NikeTown, spas and even grocery stores have begun to capitalize on the experience economy. NikeTown provides the consumer with an experience beyond the purchase. They draw consumers in by offering fun activities, fascinating displays and promotional events. They intentionally use services as the stage and the goods as the props, to engage individual customers in a way that creates a memorable experience. (Gilmore, 6) The same can hold true for the medical experience. The commercial approach to experiences translates into healthcare settings in a very similar way. By seeking to provide the consumer or patient with a positive, memorable experience the healthcare setting cannot only heal the patient, but leave them with a sense of individuality and quality care.

Orthopedic patients may return multiple times to a facility for consultations, procedures and rehabilitation. Since the majority of the injuries to orthopedic patients are not urgent or life-threatening, this patient population has a greater opportunity and pre-disposition to shop around for the best care. The perceived quality of care, derived from their experiences, may be as, or more, influential to their decision of where to seek care than actual clinical measures of quality which they may not fully be able to appreciate or understand.

To properly provide for each patient to have a unique or customizable experience, the built environment will need to adapt in some way to each patient profile’s changing needs. This can be achieved by providing options to the patients at each stage of their medical process. An example would be, rather than just providing a waiting room, provide multiple areas designated for different activities. These activities can range from providing internet access for those trying to do work while waiting, providing music booths for teenagers and a play area for children. This will present options to patients or the ability to customize their experience through a more adaptable architectural environment.

Need for Adaptability

The changing needs of the orthopedic patient population and the changing technologies associated with orthopedics require a level of adaptability within the architectural environment. This would positivity influence this particular field of medicine by providing a more customized patient experience and a higher quality of care and service to the patients. Since there are changing needs based on patient types, it is important to understand their range of limitations and abilities that will help determine the design of the physical environment.

Individuals, who have physical restrictions, can be categorized in two general areas. There are those who are permanently disabled and those who are injured and temporarily disabled. Those who are permanently disabled do not want to be seen as different or weak. Patients who are temporarily disabled are potentially in need of greater assistance. If the architectural environment can provide assistance without calling attention to physical limitations it will meet the needs and expectations of both the permanently disabled and the temporarily disabled.

Fig. 16 Scripps Rehab Center, La Jolla California

The architectural response is not limited to just providing accessibility. For example, the main entrance to Scripps Rehab Center in La Jolla, California has multiple flights of stairs and a different designated entrance for those with limited mobility. It calls attention to their limitations. (Miller, 266) Emphasis should be placed on the mobility they can achieve, but if it is not negotiable by all patients then it will instead call attention to those who cannot physically navigate it. If everyone is entering and exiting through the same route then no one feels inadequate. Furthermore, if a positive experience, such as providing desirable views is achieved from this circulation route, then the focus is placed on the experience, rather than anyone's limitations. Since many of these physical restrictions vary, such as those using crutches or those in a wheelchair, providing generous areas of circulation that can accommodate all ranges of motion is ideal.

Patients Varied Needs and Expectations: Orthopedic patients all vary in mobility and expectations. A professional athletes or Olympian could be an average adult female, in a wheelchair with a broken leg. There are ways that the built environment can accommodate for the physical restriction of a wheelchair, without compromising the experience. It can be more liberating if multiple forms of circulation and transportation are made available to someone in a wheelchair. For the patient to feel like they can choose their route or path, means they are not limited to one accessible entrance, mode of vertical circulation or waiting area. Providing multiple options can allow them to customize their overall patient experience.

Fig. 17 Professional Athletes and Olympians

The athlete has expectations of a fast recovery time, a sophisticated level of care and detailed information on diagnosis. By providing adaptability of the built environment it can change as new technologies emerge and this will provide a higher level of care throughout the life of the facility. Imaging within the surgical setting can provide access to more information about their injury for the patient. The patient demographics of athletes may be the patients most concerned with the quality of technology and innovation in the care they received.

Fig. 18 Amateur Athletes

Fig. 19 Weekend Warrior

An amateur athlete, 10-year-old boy, who has a broken right arm, might need to be provided with distractions to take his focus off his injury. This patient would also benefit from engaging activities, such as video game consoles in the waiting room and interactive videos in the exam rooms that help them learn more about their injuries. Providing access to food can provide a means of diversion as well. Areas they can easily navigate without much assistance help them to focus on the mobility they do have, rather than what they cannot do. A child has the expectations of returning to a full recovery as quick as possible. Providing an area where they can be introduced to rehabilitation efforts helps them understand what they can do on their own to speed their recovery process.

A weekend warrior who is an adult male might have problems with his left knee and is using crutches. He needs a physical environment that is extremely easy to navigate. He has expectations that are focused on rehab and preventative guidance. If the facility can provide rehabilitation settings that provide incentives for rehabilitation, someone who is typically not active on a regular basis can benefit in the long term. Providing this positive experience is essential in having an impact on the patient.

Fig. 20 Arthritis and Aging Population

Those suffering from arthritis have special needs. Patients with arthritis have great pain in their hands and feet. Doctors now know that staying active through regular exercise is one of the best things people with arthritis can do to slow the progression of their disease. It also improves physical functioning, and even reduces pain over the long term. (Boyles, 1) Providing a relaxed physical environment where these patients can stay active is important to meet their expectations of their medical experience.

Placing the rehabilitation portion of the program in a desirable location that can allow all patients to experience rehab in a more relaxed environment with positive forms of distraction will reduce their stress. Providing connections to nature and separating them physically and mentally from their busy life can help give them the peace of mind needed to focus on their recovery.

Rapidly Changing Technology: The new technologies within the fields of imaging and surgery, mentioned in the previous chapter, directly relate to orthopedic care and are so rapidly changing that it is hard to predict how they will transform in the future. Following the current trends of surgical robots, lasers, arthroscopy and medical equipment, these technologies have generally become smaller and more mobile. This allows the physical environment to be more adaptable because it is less dependent upon the technologies. If the architectural environment can allow for more flexibility to changing technologies, a higher level of patient care and recovery can be achieved.

There are now more orthopedic operations that can be performed on a more minimally invasive and out-patient basis. This allows more complex procedures to be performed in an out-patient setting such as limited incision hip replacement surgery, minimally invasive total hip replacement and unicondylar knee arthroplasty. These technological advancements reduce risks to patients, so designing to accommodate for these procedure is important.

Based on these technologies and assumptions, it would be possible to provide one room to serve multiple patient needs. A more universal room provides the opportunity to explore a more adaptable physical environment within the medical setting. A more universal room would allow for the pre-operation, procedure and recovery process to all occur within the same environment.

The ability to customize the clinical environment as needs and trends change over time would allow for a more unique and responsive patient care experience. It would be more unique because each patient would be given more options throughout their medical process. It would also provide a more responsive care because the built environment could more easily adapt to the changes in technology. Because orthopedic patients are a unique patient population and the technologies in their field are rapidly changing, there is a need for the architectural environment to easily adapt to these changing needs. The architectural environment can achieve this higher level of adaptability by introducing a form of adaptive customization into the design process. If appropriate infrastructure can support changes in technologies and if the architecture is more modular, then elements can be easily changed to accommodate varying floor configurations.

ARCHITECTURE AND ADAPTIVE CUSTOMIZATION

Emerging trends and technologies in the practice of orthopedic medicine, especially the merging of imaging and surgery, in addition to higher expectations from orthopedic patients, requires the need for the physical environment to adapt. This can be achieved through architectural strategies of adaptive customization. Adaptive customization has been applied to product design in a variety of ways. For example the automobile implements strategies of adaptive customization because it is a standard product, but can be customized in multiple ways by the users. When these forms of adaptive customization are applied to the architectural environment they have the potential to positively influence the users of that space, by providing a more customized experience that meets more of the patient's needs.

There are four specific categories of customization: adaptive, cosmetic, transparent and collaborative. (Gilmore, 94) Adaptive customization is most applicable to healthcare architecture because it provides a standardized product that the end user can adapt to their changing needs, as opposed to other forms of customization which take place during different phases of design or are more superficial. With a very high rate of change in healthcare environments, adaptability is paramount. Introducing adaptive customization can allow the physical space to change by being able to accommodate a variety of technologies from a systems perspective as well as designing an architectural setting that provides the patient's with options to customize their experience.

For many reasons, there is a great need to minimize disruptions in healthcare environments during periods of construction to update the facility for new technologies and new patient needs. Adaptive customization can reduce these disruptions and allow for a smooth transition in technologies and services as they change because the appropriate infrastructure will be provided to make these changes easier and less disruptive.

Medical technology is so rapidly advancing, making it difficult to design for the technological needs of today, when they may change before the building is even constructed. Because of these rapid changes, the built environment will need to change as well and if it is costly and time consuming to make these changes then the facility will suffer. Thus, implementing a higher level of adaptability into the architecture itself will allow for accommodation of these potential constraints caused by new construction, or the reconfiguring of an area of the facility. Adaptive customization when applied to architecture provides a flexibility of the built environment that can better accommodate the changing needs in technology and the diverse needs and expectations of orthopedic patients, practices and technologies.

Current Applications of Customization

Fig. 21 Customization Chart

Due to rapid advancements in technology, globalization of companies and consumer demand, customized products are becoming important to the competitivness and profitability of many companies. (Luximon 1) With this growing competition in businesses, satisfying customer's individual needs and requirements has become competitive. (Zhang, 1) Because of this there are a multitude of current applications of customization that provide a variety of products to consumers, such as, Dell computers, automobiles and iPods.

Most forms of customization are typically used in reference to product design, but they apply to architecture as well, and given the changing needs of the healthcare industry, are even more relevant in healthcare architecture. There are four defined categories of customization: collaborative, transparent, cosmetic and adaptive. (Gilmore, 94)

Fig. 22 Collaborative Customization – Dell Laptop

Forms of Adaptation and Customization: Collaborative customization is when consumers or end users have input in some way, with the design and manufacturing of a product to determine the precise characteristics or features that best serves the customer's needs. This information is then used to specify and manufacture a distinctive and relatively unique product that suits the individual customer. For example, Dell will prompt customers to specify their exact needs, by presenting a multitude of options for each specific need pertaining to the purchase of their computer. These range from the color of the exterior to the precise details of the software that is to be run on the computer. After asking all questions pertaining to the purchase, the information is then translated to the assembly line and a unique computer specified by the customer is produced.

From the architectural perspective, collaborative customization is generally the way architecture is currently designed. Architects and clients or hospital administrators, work together, through a series of meetings discussing needs, expectations and limitations of their intended project. These meetings and work sessions ultimately seek to design a product or building that fits the discussed needs. However, given the extensive time it takes to design and build a hospital, it is inevitable that staff turnover, at both the design firm and the hospital will occur. This creates a disconnect between the decision making process of the original meetings and the ultimate occupancy of the users of that facility. So, the end product hopes to meet the foreseeable needs and future needs of the facility, although sometimes achieving either one of these is not possible.

When collaborative customization is applied to product design, the same issues hold true. A dell laptop can be customized to the customer's needs online, but when their needs change a new laptop may ultimately need to be purchased to fully satisfy their new desires. Of course, there are ways to add memory or RAM, but, eventually the technology will have advanced to the point that the hard drive of the laptop can no longer properly run current programs. Sometimes the cost of upgrading the computer is more expensive than just purchasing a new one. Collaborate customization is a process that should be employed in the design of healthcare settings and often creates a better initial product, but is not necessarily geared to producing products or architecture that can be adapted after the preliminary customization.

Fig. 23 Transparent Customization – Amazon

Transparent customization is when companies make unique products or services available to individual customers, without explicitly telling them that the products are customized to their individual needs or purchasing habits. In this case, it is essential to accurately assess customer needs. For example, Amazon will take information from a customer's previous orders and when the consumer returns to Amazon, they automatically offer similar purchases based on the information they previously gathered about the consumer.

Transparent customization is traditionally used in architecture to design a building that does not have a set user or client. The design is based on gathered data on the typical market segment. The space is being designed to accommodate these sectors and is trying to anticipate the range of requirements of the potential users. An architectural example of transparent customization would be a commercial or medical office building built by a developer and containing shelled space for lease.

Transparent customization may work well in product design, when assessing typical consumer needs and marketing a new product. For example, Coke will occasionally attempt, after having researched consumer's preference, to market a new Coke related product. The research and market studies may have found statistical data that would result in success of the new product. Sometimes this results in a popular new soft drink, other times the drink fails to connect with the target audience. This form of customization is not as desirable when applied to healthcare architecture given a building's cost requirements and more permanent nature.

Fig. 24 Cosmetic Customization – Child's Camera

Cosmetic customization is a standardized physical product that is marketed to different customers in unique ways. It is simply taking a product, with the same functional capabilities and packaging it in a different way to appeal to a specific consumer. For example, a camera that is packaged to appeal to a child, but is still a working camera that functions the same as any other camera. Only the product representation changes, such as the skin or packaging of the camera. These changes are only meant to target a younger audience. Another example of cosmetic customization is the iPod. Buyers can choose the color of their iPod and have designs or names picked out to have stamped on the backs. This is simply a change to the exterior of a standardized product.

Cosmetic customization is applied to architecture in the same way it is applied to product design. It is often used in healthcare architecture when designing a children's hospital. Bright colors and even cartoon characters are used to superficially decorate in a "child-like" way an otherwise standardized nursing unit or hospital planning concept that would also be applicable for other patient populations. Cosmetic customization in architecture is focused on image. The customization process is more superficial and has little to do with the function of the space and does not address flexibility of the building. However, architecture is experienced by more than just the direct user themselves. If it is only meant to be customized to attract one audience, it is possible that it will not appeal to others. So a superficial, packaging approach with little to no further design intent could potentially leave the architecture lacking in other areas of the design.

Adaptive customization pertains to standardized products that are customizable in the hands of the end-user. The customers alter the product themselves. For example, automobiles are manufactured in many makes and models each model is a standard product, but it can be

Fig. 25 Adaptive Customization – Automobile

manipulated and customized by the drivers and users according to their specific needs. An automobile can adapt in many different ways, the rear seats can collapse to allow more room for storage or supplies. Racks can be attached to the roof for skis, bikes or luggage. The driver's seat can be adapted to ergonomically fit each driver best and then can be programmed to adjust according to the different drivers.

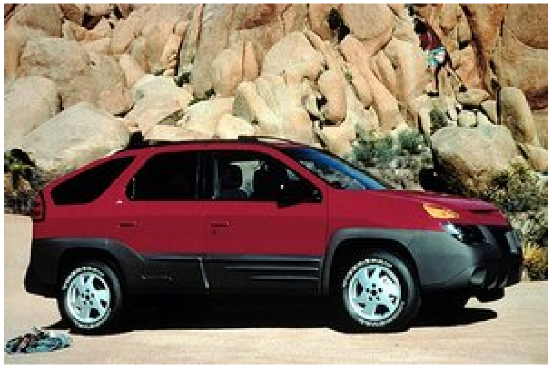


Fig. 26 Pontiac Aztec

The Pontiac Aztec is a highly versatile, minivan-like vehicle. It can easily adapt into something similar to a camper, with a built in tent extension for the rear gate. It also boasts rooms for air mattresses in the rear and a center console that doubles as a cooler. The automobile industry has found a way to offer a wide variety of different models and at the same time allowing the freedom for each user to adapt one particular model to fit their specific needs.


Fig. 27 Pontiac Aztec with Camper Extension

Adaptive customization is the ideal form of customization to be applied to healthcare architecture. Healthcare architecture, compared to other typologies of architecture becomes more quickly out-dated. This is due in part to the rapid advances in technology and changing patient care needs. However, it is also because the buildings do not always allow for future growth and adaptability overtime. Since a building is such a large cost investment it should satisfy and be able to adapt to the user's needs well beyond its initial conception.

Adaptive customization, when applied to architecture, provides the appropriate infrastructure that makes change and adaptability at the building scale possible. If systems and utilities are strategically located, a more open floor plate becomes possible. This allows the users to adapt the space as their needs change. A building designed for one specific scenario or need with all supporting spaces, structure and utilities related to that one design, makes future changes difficult. Change and adaptability for the future become more disruptive. It is ideal to minimize these disruptions because the longer the client must live with their investment, and the building satisfies their needs, arguably, the more successful the design. Adaptive customization, based on the research of customization and the definition of each category is the most advantageous implementation of customization to the architectural environment. The application of adaptive customization to architecture creates a building that adapts rather than stagnates; responds to change rather than rejects it; is motive rather than static.

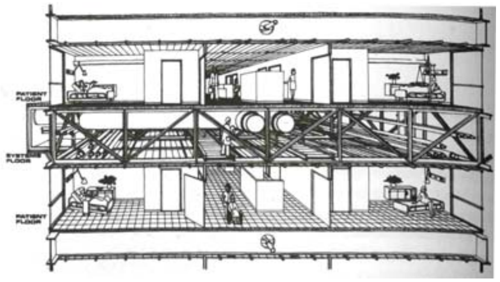


Fig. 28 VA Interstitial system, section

Applications of Designed Adaptability and Customization in Healthcare: The VA Building System hospitals achieved a higher level of systems and design flexibility than hospitals designed without future flexibility in mind. They were originally intended to be "obsolescence-proof" as stated at the World Hospital Conference and easily accommodate the hospital's needs for at least the next 40 years and beyond. (Zeidler, 1974) In the late 1960's, the U.S. Veterans Administration required all their hospitals to be built with interstitial space or a floor between floors, used as service space to support adjacent functional spaces. The intent was to provide a more flexible area for rapidly advancing medical technologies. (Verderber, 120) The VA systems or IBS (Integrated Building Systems) approach to design sought to accommodate technological and operational changes that would need to occur, by compartmentalizing the entire building into a physical framework of structure, mechanical and life safety systems. The IBS approach to interstitial space accommodated all mechanical distribution systems and designated subzones for each

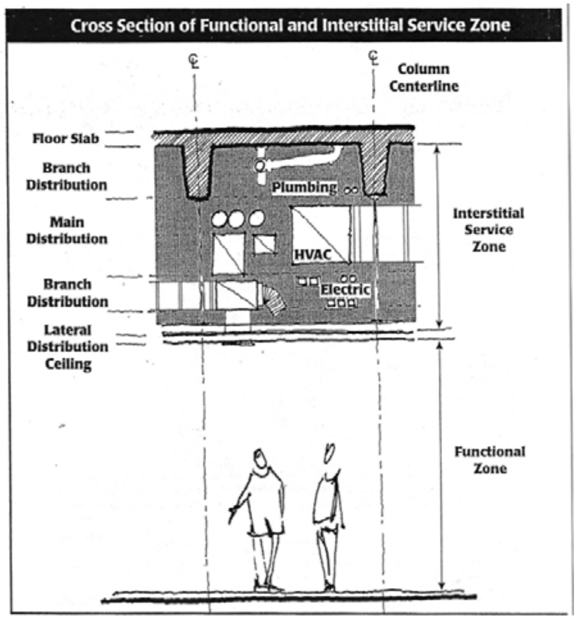


Fig. 29 IBS Cross Section of Functional and Interstitial Service Zones

specific system. This made access to all systems easier for maintenance, adjustments and changes, with minimal disruption to functional spaces.

Interstitial spaces were implemented and applied to all parts of these hospitals, so that a patient floor could be converted to a research floor and the support would already be in place. It provided a great deal of flexibility for the future by allowing the building to change and adapt as the user's needs changed. However, due to the sheer mass of these generally large teaching hospitals, interstitial space between each large floor plate seemed somewhat copious. (Verderber, 120) And, as ideas of interstitial space began to translate into the built environment a trend occurred in patient care that shifted away from highly centralized, over-scaled facilities, toward smaller, decentralized facilities. The VA had failed to recognize this shift and as a result these large facilities were criticized for a lack of human scale, as well as, for having vast zones of windowless space at the core of their hospital designs. This gave the impression that they were lifeless spaces that neglected human concerns. Thus these hospitals were fundamentally flexible and provided the ability for adaptive customization to occur, but failed to create a more therapeutic and patient centered environment. (Verderber, 126)

Another application of designed adaptability in healthcare is based on the notion of the hospital as a city. This approach defines zones of flexible or soft space into blocks that are analogous to city blocks. Arguing that a city block or adaptable space that is too small limits change and when the block is too large they are too difficult to serve. (Allison, 46) However, a more ideal structural system that could provide column free planning zones, would be inherently more flexible and would allow for a more adaptable and customizable floor plate. This is especially important when accommodating the changing needs of medical facilities.

Fig. 30 Ether Dome Massachusetts's General Hospital

An example of dramatic change over the life of a hospital structure is represented by surgical suites that have changed significantly and consistently over the past 150 years. At Massachusetts's General Hospital, the original surgical amphitheater - the Ether Dome used from 1821 to 1868 - is on the top floor of the hospital. It is flooded with light from sky-lights and provides stadium seating within the operating room for viewing procedures. (Clemons,

164) As medical practices changed, from the advent of anesthesia to the development of the germ theory, the operating suite developed into a more closed, sterile environment. Operating rooms have also, increasingly grown in size to accommodate advances in medicine, new equipment and procedures. And as cited before, now imaging equipment is being consistently used in the operating room and will most likely cause another major shift in the design of the surgical environment. It is difficult to predict how and in what ways operating suites will change in the future. Thus, a structural system that provides an open floor plate, rather than structure based on a set grid, will better accommodate for the changes of the future and ultimately, will be more adaptable.

Open Building is the term used to indicate a number of different, but related ideas about the making of adaptable environments and includes design approaches, such as the VA IBS systems approach. (Kendall, 5) The Open Building Systems approach to design has certain principles that are advantageous when designing for adaptability. Most commonly open building systems are in reference to a “support and in-fill” approach to design. This is defined by designing a structure and necessary mechanical, electrical and plumbing infrastructure that can accommodate a variety of floor plan designs. Then other designers and architects can plan and design within the given infrastructure as the user's needs change. According to the open building website (www.open-building.org) (Kendall, 1) there are numerous open building principles that are relative when designing for adaptability.

An open building design principle that helps define the need for adaptive customization is the idea that the built environment is in constant transformation and that change must be recognized and understood. (Kendall, 2) This is particularly true for medical facilities as change typically occurs more rapidly in those environments than other architectural settings. Recognizing this need for constant transformation is the driving force behind designing a built environment that can be adaptable as needs change. This means that in the design process, the built environment should not be thought of as a static element and not just be designed for one purpose. Instead it needs to recognize the need and the inevitability of change in architecture and be designed so adaptability can occur.

An open building design principle that relates to the concept of designing for adaptive customization is the idea that users and inhabitants may make design decisions as well. (Kendall, 2) This design principle of open buildings recognizes that changes will be made to the built environment by the users. This is fundamentally a principle of adaptive customization when it is applied to a product or to the built environment. It can be achieved by providing the needed structural elements of the building, the required circulation and utilities and then leaving the floor plates free of these elements. This allows the users to change these spaces as they need, without requiring major construction.


Fig. 31 INO Hospital, light wells

An example of the implementation of the principles of open building systems that relate to adaptive customization is the INO hospital in Bern, Switzerland. (Kendall, 9) What makes this example different from the VA IBS approach to flexibility is the INO hospital does not have interstitial space. Instead, it has floor areas between the column grid that can be removed to allow for stairs, MEP linkages, and natural light. These areas can also be used to provide room and view relationships between areas or they can be closed off with varying materials. (Kendall, 9) This relates to the idea of adaptive customization because it allows the users to change the space in a variety of ways. However, the set column grid throughout the building does not allow for an open floor plate and this could limit the overall customization of the design.


Fig. 32 Mobile C-arm

Mobile medical equipment is another application of designed adaptability within the healthcare setting. It relates to adaptive customization because it is a standard product that allows the users to customize the equipment from the standpoint of move ability. It is ideal in healthcare design because it allows the architecture to be free of the constraints of fixed equipment. This is advantageous since medical equipment and technology changes so rapidly and mobile equipment does not always require the architectural environment to change. COWs, or Computers on Wheels, are easily transportable. They can be customized by nurses according to their height and they can provide an area for frequently used supplies. COWs can help reduced the number of steps nurses have to take because they do not always need to travel back to the nurse station for charting. They streamline the workflow so clinicians have more time to spend on patient care. Mobile C-arms used in minimally invasive surgical procedures provide portability, maneuverability and a compact design for a facility's imaging needs. One of the most important aspects of mobile C-arms is that they can be used in multiple procedure rooms. Mobile equipment allows a procedure room to be designed in a more standard, universal way because different kinds of equipment can be brought into one room, instead of the room being designed around one specific piece of equipment. Mobile equipment helps support the idea of architectural adaptive customization because it does not limit the architecture by needing to be supported by the structure or needing to be attached directly to the utilities of the building.

There is a need in healthcare architecture for adaptive customization because of the rapid changes in medical technology, medical practices, and the need to maintain consistent operations without major disruptions during periods of change. As consumer demand for more customizable products and experiences increases, that demand will extend to the field of architecture as well. If the built environment could implement qualities of customization similar to the automotive industry, which provides a standard product that can be manipulated in a variety of ways, it would prove advantageous to the architectural environment. Just as the back seats of a car fold down to allow for storage, architecture could become more adaptable by providing ease of transition between varying configurations. This can be achieved, in similar ways as open building and VA systems, by providing fixed elements that serve zones of the building that are identified as adaptable. Adaptive customization when applied to healthcare architecture seeks to provide a more adaptable built environment that can accommodate changes in technology and medical practices, while also providing a level of user adaptability.


Fig. 33 Construction Disruption

Need to Minimize Disruptions: In healthcare environments there is a great need to minimize disruptions for many reasons and the forms of adaptability summarized above, when considered during the design process, can decrease these disruptions.

The portions of health facilities under construction must be hermetically sealed to prevent dust, gases and debris associated with construction from contaminating the air of the healthcare environment. This creates logistical issues for construction workers because the workers must minimize their construction area and potentially work in stages adding time to projects. If adaptive customization is employed when initially designing a health facility, it should provide areas of the building that can be accessible solely for the purpose of changing the systems within the building or adjusting them. If there is a need to change an office area into a procedure room, the changes that need to occur, pertaining to lighting, ventilation and medical gases can all be adjusted from within a served zone or interstitial space. Thus minimizing the amount of time needed to adapt the room from within the functioning portion of the facility.

The added cost of renovating buildings where change has not been anticipated or planned for is usually far greater than having planned for change in the upfront cost of construction. Adaptive customization can help reduce the cost of renovations because change has been designed for. The renovation process should be more easily accommodated because infrastructure for change has been designed into the building and adapting to meet the needs of the facility takes less time and effort and causes less overall disturbance of the facility.

The potential loss of patients and valuable medical professionals is a risk for facilities when portions of the building are under-construction for large amounts of time. The construction can compromise the effective delivery of care by potentially needing to shut down portions of the building or by providing inadequate access to certain areas of the facility. This can deter patients from using the facility. Adaptive customization when applied to architecture should provide areas of the building that are designated to serving the rest of the facility. Therefore, if a portion of the building needs to be changed, major construction is not necessary. If major changes do need to occur, they can be accommodated in interstitial space, out of the way of the facility's daily services.

Forms of adaptability that have been used in healthcare settings have provided a more flexible form of architecture. Ideally this level of adaptability could also achieve a form of customization that responds to consumer demands and addresses the needs of the patients, family and staff. This would help provide the users with a more customized experience because they could more easily adapt the building as their needs changed. This could also provide a higher level of medical care over the life of the facility because utilities and services could be more easily accessed, upgraded and changed. If a form of adaptability is desired, it can be achieved through a prescribed set of design principles. These will serve to architecturally direct a concept of adaptive customization.

DESIGN PRINCIPLES

Applying adaptive customization to architecture requires a prescribed set of design principles that provide guidelines for ensuring a more adaptable built environment. These principles have been defined to apply at multiple levels of scale and to be applicable as the building changes over time. They are intended to provide a sense of timelessness to certain elements of the facility, so that it can easily adapt as the needs of its users and the technologies change.

First, the building should be conceived as a dynamic physical interface between the contextual or external environment, programmatic internal spaces and the forces of change associated with these areas. This is so that the exterior façade of the building does not inhibit internal change and can also respond to external changes. In order to allow for growth and change of functional areas over time, all mechanical, electrical and plumbing utilities should be organized into distinct service zones. These service areas and elements should be expressed as a design feature. The facility should accommodate and celebrate varied modes of mobility so that people with a range of disabilities and abilities, can freely navigate the building and not feel intimidated or segregated. The building should also implement active forms of program that are the functional areas of the building and re-active forms that serve the active, functional areas. These principles are intended to assist in the design process of an architecture that achieves adaptive customization.

Dynamic Building Envelope

Fig. 34 CalTrans Building by Morphosis
Example of a Dynamic Building Envelope

The building should have a dynamic envelope. The façade should be capable of reacting to a changing contextual or external environment. It should also be able to respond to the programmatic internal spaces and changes associated with these areas. In this way the skin of the building acts as a flexible edge condition and can be treated in different ways, according to the program of the interior spaces.

This is essential so that the exterior façade of the building does not inhibit internal change and can also respond to external changes. It is also important so the interior can be modified, without disrupting the overall exterior visual order of the building. This allows the façade or skin condition of the building to be adaptable itself.

It is most critical that the building envelope be most dynamic at the exterior walls of the designated adaptable functional areas within the facility. These are the areas of the building that will accommodate changes in programmatic needs. Walls will meet the exterior of the building in different areas as rooms and interior spaces change and the façade needs to allow for these varying conditions.

A dynamic envelope should also be used on the exterior walls of the utility spaces of the facility. These are the areas that will accommodate technological, mechanical and system changes throughout the life of the building. These utilities will have vents and ducts associated with them and as the systems change so will the way in which they converge with the exterior façade. Thus a building envelope that can accommodate for the changes in utilities without disturbing the general exterior image of the building should be achieved.

A more dynamic building envelope can achieved in numerous ways through the application of moveable shutters, motorized shade devices, screening systems or automatic tint or frosting glass. A more dynamic, reactive skin can also be obtained by using a double-skin façade. This is when any two materials are used to create the exterior facade of the building. This can be two layers of glass, or a layer of glass and a screening device, or glass and a more permanent wall behind it. One material meets the outside condition of the building and

Fig. 35 CalTrans Building by Morphosis

Fig. 36 CalTrans Building by Morphosis, Double Wall System

the other material the interior. Dynamic, double-skin walls also induce air movement between the layers of glass and allow for thermal comfort within the building and better acoustical quality throughout the facility. (Ting, 2)

The Caltrans Building designed by Morph sis has a double-skin wall system that allows for the interior program to change and the walls to move, but the exterior façade or overall look of the building remains consistent. The skin can be open or closed depending on the conditions of outside temperature and sunlight. At dusk the building is transparent -textured and windowed everywhere, while at mid-day it is buttoned up against the sun, appearing to be devoid of windows entirely. At night, the dark facade seems to recede to enhance other areas of the building.

A dynamic building envelope was also achieved in the Milwaukee Art Museum designed by Santiago Calatrava Valls. It has large wing-like brise soleil that can be opened or closed by the museum depending upon the weather or the needs of the programmatic space within the art museum. (Aldersey-Williams, 51) In this way the exterior façade is adaptable by the


Fig. 37 Milwaukee Art Museum

users depending upon their given needs. It allows the exterior façade to transform as the exterior contextual environment changes. The exterior façade can also adapt to suit the needs of the program or art installation within the museum. For example, if the installation has media projected and needs shading from the sun, the façade could transform to meet those needs. A dynamic building envelope will support changing external and internal conditions of the building.

Co-location of Utilities as Distinct Design Element

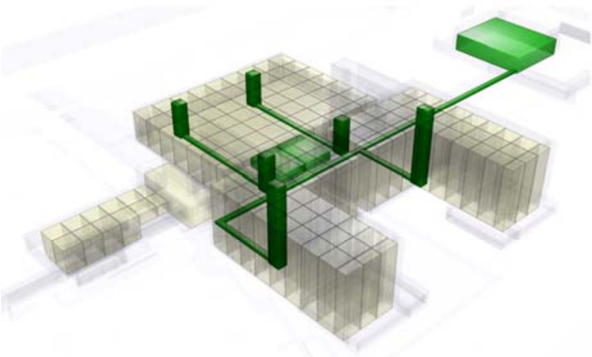


Fig. 38 Concept Model, NBBJ Architects

All utilities such as mechanical, electrical and plumbing services should be co-located and act as a distinct design element of the building. The co-location of all utilities can allow for a more open and adaptable floor plate. It also allows for ease of access and servicing of the utilities because they are all in one location. Since the utilities that service healthcare buildings require a large amount of square footage they should be designed as a significant feature. If they are not designed to be a distinct element they will stand out in the overall building form anyway because of their large volume. So, designing and incorporating them into the overall building design is ideal.

Co-location of the utilities is important to achieve a higher level of adaptability throughout the building. When designing for adaptive customization it is critical that services can be easily accessed and changed over time and with distinct zones of serviceable space, this is more easily achieved.

Fig. 39 Interstitial Space

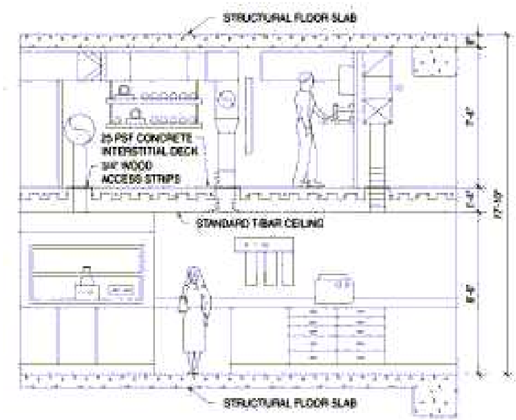


Fig. 40 Diagram of Interstitial Space

The co-location of utilities pertains to HVAC, plumbing, mechanical areas associated with equipment and all required vertical circulation elements that supply support to more flexible and adaptable portions of the program. These elements are the more static, unchanging and permanent parts of the building space plan.

The co-location of utilities can be achieved in multiple ways. The VA hospital systems co-located utilities in a horizontal fashion throughout the building with the implementation of interstitial space. Interstitial space allows for ease of access to the utilities and for a more adaptable zone of functional space. This arrangement uses an accessible space above the ceiling plane with a floor for access and a low vertical height to accomplish a horizontal distribution of systems. The HVAC and services drop or rise vertically from this space into the program spaces. They provide excellent access for maintenance personnel. Vertical shafts at the perimeter or in a central core connect interstitial space services with the entire building. (Cooper, 1994)


Fig. 41 Sendai Mediatech

Co-location of utilities could also be accomplished as in Sendai Mediatech in Sendai-shi, Japan. Tubes throughout the building not only provide areas for utilities, but light and structure as well. The tubes provide for networks and systems that allow for technological communication and provide space for all vertical mobility, including elevators and stairs. (Horsley, 12) Each vertical shaft varies in diameter and is independent of the façade. In this way the co-location of utilities and more static required spaces function as a distinct design element as well.

Create a Unique Experience through Varied Modes of Mobility


Fig. 42 HOK Architects, Celebrating Varied Modes of Mobility

The facility should accommodate and celebrate modes of mobility, so people with varied disabilities and abilities can freely navigate the building and not feel intimidated or segregated. When designing for adaptive customization it is important that the building be capable of accommodating or adapting to meet the needs of all users. Creating a unique experience out of varied modes of mobility should be an expression and celebration of the users who adapt and occupy the space.

A facility designed for orthopedics patients needs to not only physically accommodate them, but make a positive experience out of their varying personal abilities. If a variety of forms of mobility are used throughout the building, the facility feels more accessible. It is even more desirable if a positive and unique experience can be achieved in these areas.

Creating a unique experience through varied modes of mobility should be applied, as much as possible, in areas of circulation and navigation throughout the building. Emphasis should

Fig. 43 Celebratory Elevator at the City of Arts and Sciences

Fig. 44 Richard Rogers building

be placed on these areas because they are the most difficult obstacles for orthopedic patients. Making a memorable, positive encounter with varying modes of circulation and mobility will enhance their experience.

Celebrating varied modes of mobility can be achieved architecturally in many ways, such as, glass elevators and celebratory ramps. The City of Arts and Sciences designed by Santiago Calatrava Valls in Valencia, Spain has a hydraulic elevator, providing access through the center of the building. (Alexander, 138) It is a unique design feature that celebrates varied modes of mobility through the building. Celebrating varied modes of mobility cannot be achieved with staircases or escalators because not everyone can easily negotiate these. There are many architectural projects that celebrate circulation and mobility.

Selected Works from HOK Architects and Richard Rogers celebrate the circulation by emphasizing and highlighting modes of mobility on the exterior of the buildings. Richard Rogers does this by pulling the circulation to the exterior of the façade and using a glass elevator to display the circulation.

Provide for a High Level of User Adaptability in Functional Zones

Fig. 45 Banner Estrella Medical Center, NBBJ Architects, Hinged Space

Healthcare buildings must have functional, served zones that can be easily adaptable, by facility managers, to changing technologies, medical practice and patient needs with minimal operational disruption. Changes can occur easily in service zones as well. These areas need to support the functional regions of the building. The level of adaptability should reduce construction time and disruption to the facility as spaces are modified according to changing needs.

This is important because medical facilities use technologies that are changing at a rapid rate. Change causes disruptions to the daily activities of the facility when they need to be altered and there is a need to minimize these interruptions. Typically these disruptions are caused by changes in the utilities that serve functional areas. If the service zones are easily accessible and can be altered without disturbing functional areas, then other changes, such as adjusting the location of a wall, is all that needs to occur within the functional areas.

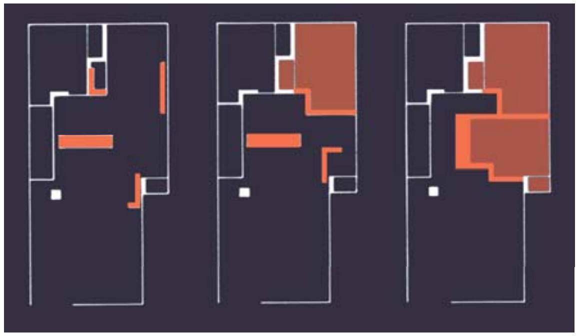


Fig. 46 Hinged walls in apartment building in Japan

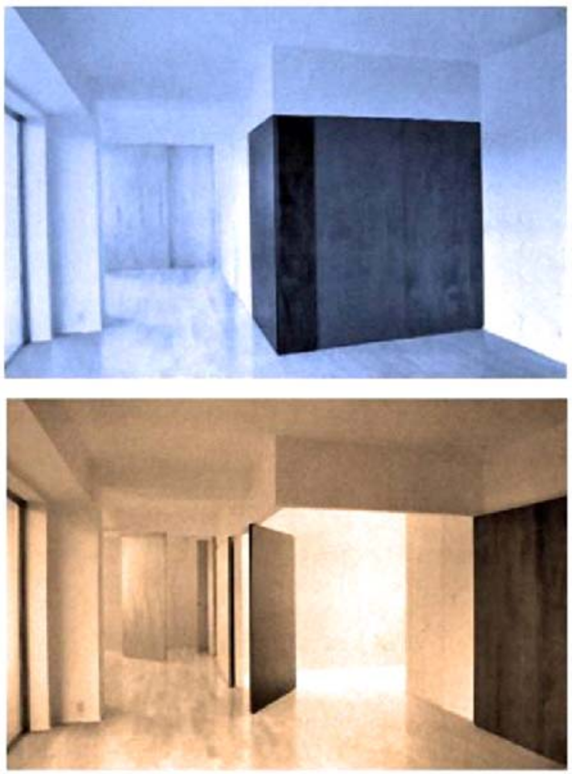


Fig. 47 Hinged walls, closed and opened

A level of user adaptability should be achieved in the service areas of the facility. If they are designed to be accessible and easily adaptable then this will create an uncomplicated transition between new technologies and programmatic changes within functional areas of the building. If a higher level of adaptability can be achieved in the functional zones as well, this would be advantageous. If all walls, ceiling and floor are on a set grid, it will make moving walls, changing ceilings and accessing floors easier.

A higher level of user adaptability can be architecturally achieved in multiple ways, such as using hinged walls, raised floors, dropped ceilings and accessible service zones. Hinged walls were used in an apartment building designed by Steven Holl, in Fukuoka, Japan. The interiors are conceptualized as “hinged spaces.” These allow for expansion of the living areas during the day and then the space can be reclaimed by the bedrooms at night. (Schwartz-Clauss, 57) This allows the users of the space the ability to manipulate and adapt their own spaces.

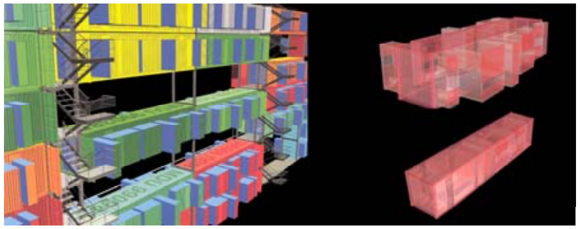


Fig. 48 Mobile Dwelling Unit, Lot-ek

The Mobile Dwelling Unit by Lot-ek Architects is an example of another way to achieve user adaptability. The units or dwellings are constructed out of shipping containers. They can be pulled out in certain areas by the owners and users themselves to create hallways that connect the different units or rooms and then fit back together for ease of transportation. (Scoates, 38) It allows the users to adapt the space in a variety of ways and with minimal disruptions.

Create Re-active or Supporting Program and Active Program

Fig. 49 “In the space between my fingers lives another hand” Leo Vroman

The active or programmed portions of the building should be supported by service or re-active areas. Leo Vroman said “In the space between my fingers lives another hand.” (Hertzberger, 51) This means that spaces between active forms have value as well. In this same way the spaces between the programmed portions of the building are assigned a purpose, either to provide service to the programmed space or to add a distinct design feature to the space. In this case, the purpose of these re-active areas is to service the active programmed spaces. Explain in a way that can be applied specifically to a building and show an example of what you mean in a relevant precedent on this page.

This is important when designing for adaptive customization because the programmed spaces need support spaces, so they can be more easily transformed and adapted. This is also important when designing health facilities because the functional areas of the building require a large amount of utilities or support spaces. Creating a physical relationship between these areas is critical to the success of a more adaptable programmed space. If the re-active

Fig. 50 Section of Active Program and Re-active / Support Program

or supporting program space can adapt and change as the active forms need it to, then it will better serve the functional program area.

An example of re-thinking the relationships between zones of space is expressed in an underground parking garage in Basel, Switzerland. Acconci Studio Architects designed the ground plane above the garage to be strips of park. These strips let sunlight down into the parking garage and at night, artificial light up onto the park strips from the parking garage below. (Calderon, 36) Rather than design an underground park that had no relationship to the park above, they designed each as active and reactive forms that provide purpose to the other and create a relationship between adjacent spaces. This could be achieved in the sectional quality of a space, by allowing the ceiling plane to change heights to provide different relationships between the active program area and the support space.

Fig. 51 Underground Parking Garage, Acconci Studio

The design principles of adaptive customization seek to define the criteria by which the architecture can adapt to the user's needs. If these principles are implemented into the overall design of an orthopedic facility it should exemplify a level of adaptability that can accommodate the varying user needs, the shifts in medical technology and medical practice while minimizing disruptions during periods of change. These principles should support the overriding design of the facility, but also sustain a program that allows for adaptation.

A PROGRAM OF ADAPTATION

The initial functional program for the proposed out-patient orthopedic facility in this thesis has been developed according to the current and projected needs of the patient population and the technological requirements of the facility. The proposed orthopedic facility is programmed to serve as an out-patient setting both initially, and in the future, where admitting, diagnosing and treating patients occurs without requiring an overnight in-patient stay. It includes spaces for support, exam and procedure rooms, rehabilitation components and public and administrative areas.

The functional program has specifically been considered to accommodate for the adaptation of the physical environment by developing multiple programs based on likely case scenarios. A loose fit long life programming strategy was employed and achieved by developing and programming for multiple potential circumstances. The concept is to structure the program into different phases and plan for each, to confirm that adaptation for both known and predictable futures can occur. By employing and programming for an open infrastructure based on the principle of adaptive customization, it is anticipated that the changes between each scenario can occur easily. This will also hopefully allow for the accommodation of unknown futures as well.

A Program of Various Potential Futures

Since the driving and consistent programming goal is to respond to the needs of an out-patient orthopedic surgical facility, then devising varying program scenarios for multiple levels of surgical acuity is advantageous to test for flexibility. This is most easily achieved by defining two different zones within the building, the static program areas that will be relatively unchanging, support and service spaces that will chage internally but not in terms of location and general configuration, and the adaptable zones of the building that must be designed for adaptability and many potential configurations.

Static Program: These areas of the program will be classified as service spaces and public zones of the building and will, for the most part, remain unchanged and will provide services and support to the areas of adaptability. The infrastructure or support spaces will mostly consist of utility and interstitial spaces throughout the building. This is where HVAC, mechanical, electrical and plumbing will run. All ductwork, gases and data wiring will travel throughout these spaces. These spaces will be accessible for maintenance personnel so that utilities should be serviced, upgraded and moved more easily. The public zones that will remain static include the lobby, waiting and reception areas. This also includes public restrooms and elevator lobbies. These public zones are meant to provide overall and consistent spatial organization and circulation cues and pathways throughout the building. These areas are static and fixed to the degree that there physical location will not change however this does not mean that these spaces will not change in character or specific secondary use within those areas overtime. For example, the waiting area may adapt as patient's needs change, but the physical location of the lobbies and waiting area will remain the same.

The primary activities located within the public zones of the facility in addition to corridors lobbies, stairs and elevators, are the café and the ramp. The café will be accessible to the general public. It will serve as a small gathering place for those who work in the building and surrounding buildings. It is not located adjacent to from the waiting area, but is still accessible from that space. The ramp is to serve a variety of functions. It is mostly intended for the staff and patients of the orthopedic facility. They can use the ramp to travel throughout the building in a more calm and relaxing way and it encourages the orthopedic patients to be more active, yet is easy enough for most all patients to navigate.

The administrative spaces of the building are to function as static support spaces. They are located on the fourth floor, and while over time they may adapt to changing needs, they are not the focus of adaptability in this body of work. Thus, they will be classified as a support area, serving the adaptable areas of the building. The administrative program includes offices, conference rooms, consult rooms and a large staff lounge. There is also a portion of the floor that is an open office area and allows the floor to grow over time as needs change.

Rehabilitation services are classified as a static programmatic element as well. This is because the central focus for adaptability has been placed on the programmatic areas of the building that will be highly influenced by technological and medical practice trends as well as patient's needs. The rehabilitation component, located on the top floor, will provide outdoor areas where patients can focus on physical recovery. The rehabilitation area also includes an open gym and accessible locker rooms for patients.

Static Program	# of Rooms	Unit Area	Total Area
Public Areas			
Waiting Area / Receptionist	1	1161 SF	1161 SF
Lobby	1	1391 SF	1391 SF
Cafe	1	186 SF	186 SF
Water Fountain	1	29 SF	29 SF
Public Toilet	1	68 SF	68 SF
Elevator Lobby	4	435 SF	1740 SF
Public Restrooms	1	350 SF	350 SF
Public Restroom	2	71 SF	142 SF
Total			**5067 SF**
Administration Spaces			
Staff Restrooms	1	244 SF	244 SF
Staff Toilet	1	74 SF	74 SF
Conference Room	1	299 SF	299 SF
Supply / Storage Room	1	311 SF	311 SF
Copy Room	1	309 SF	309 SF
Consult Room	3	138 SF	414 SF
Nurse Manager Office	1	138 SF	138 SF
Storage	1	92 SF	92 SF
Physician Office	5	144 SF	720 SF
Staff Lounge Area	1	445 SF	445 SF
Open Conference Area	2	263 SF	526 SF
Open Office Area	1	2131 SF	2131 SF
Total			**5703 SF**

Fig. 52 Space List of Static Program 1

Rehabilitation Services			
Laundry Room	1	143 SF	143 SF
Spa / Therapy Room	1	209 SF	209 SF
Stress Test Room	1	157 SF	157 SF
Strength and Conditioning Offices	1	251 SF	251 SF
Classroom	1	223 SF	223 SF
Body Weight Testing Room	1	186 SF	186 SF
Trainer Office	1	138 SF	138 SF
Sports Psychologist Office	1	139 SF	139 SF
Open Gym	1	1319 SF	1319 SF
Outdoor Stretch / Rehabilitation Area	1	3158 SF	3158 SF
Men's Locker Room	1	463 SF	463 SF
Women's Locker Room	1	698 SF	698 SF
Storage	1	209 SF	209 SF
Total			**7293 SF**
Infrastructure / Support			
Basement/Shell/Utilities	1	14251 SF	14251 SF
Greeter	1	104 SF	104 SF
Mechanical/Electrical/Plumbing	1	728 SF	728 SF
IT Closet	5	98 SF	490 SF
EVS Closet	5	41 SF	205 SF
Elevator Mechical Room	1	58 SF	58 SF
Patient Toilet	1	72 SF	72 SF
Family Waiting Area	1	238 SF	238 SF
Total			**16146 SF**
Net Area			**34,209 SF**
Gross Area			**55,600 SF**
Net to Gross (multiplier)			**1.63**

Fig. 53 Space List of Static Program 2

Adaptable Program: The portions of the program that will need to be highly adaptable are the areas of the building that are most affected by technological and medical practice trends and the changing needs of orthopedic patients. These areas include the exam, diagnostic and procedure rooms, as well as the pre-op and recovery areas.

The exam rooms serve patients who need to be examined to determine their specific medical needs. Activities within the exam rooms are patient charting and assessment. The exam rooms will need to be large enough for a C-arm and other mobile imaging equipment. The exam rooms will also serve as a prep room for those using the Orthone MRI for diagnosis. Exam rooms are needed when the facility is offering more high acuity surgical needs, however, as technology changes overtime, the procedure rooms may become smaller and thus the facility would have a larger number of these spaces. When this occurs, the activities within the exam rooms may just occur within the procedure room itself.

Diagnostic rooms within the orthopedic facility consist of the areas containing the Orthone MRIs. Other diagnostic imaging needs can be accessed by mobile imaging equipment and

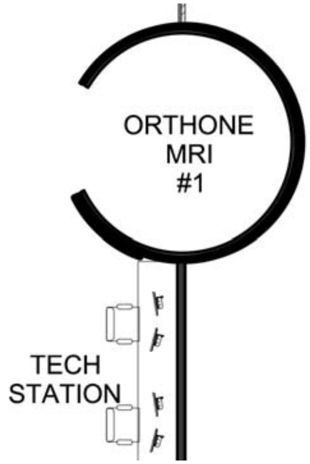


Fig. 54 Plan of Orthone MRI

used within the exam or procedure rooms, but the Orthone MRI requires copper shielding and because of this has its own room. Patients will leave the exam rooms and sit within the Orthone MRI area, while a technician performs the scan of their limb. Currently, there are no trends within the field of imaging that would not require shielding for MRIs because they use such a large magnet. (Rostenberg, 113) Thus, the Orthone MRI rooms will always need to be separate from exam and procedure rooms. They are adaptable to the degree that the copper shielding has been designed to be free of the more permanent built walls within the facility. This would allow these spaces to more easily move within the building if need be.

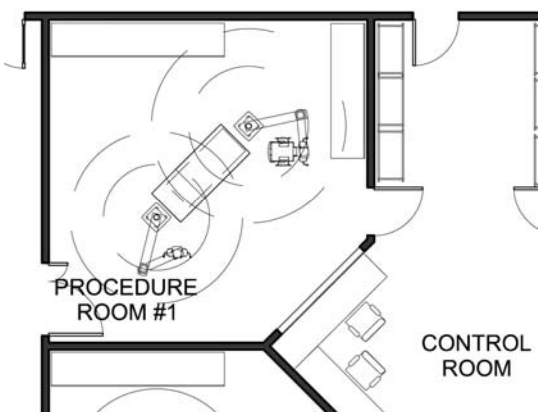


Fig. 55 Plan of a Procedure Room

Procedure rooms are the areas of the facility where orthopedic surgery will be performed. These rooms need to accommodate for imaging and surgical needs. This will require enough physical space to accommodate a C-arm and other future imaging technologies. These rooms will also be required to have viewing windows to technician work areas. Surgical lights and all monitors will be required in each procedure room as well. The requirements for the procedure rooms will change as technology advances. The changes associated with the procedure rooms is the hinge-point for the rest of the design of the adaptable area. As the technology and medical trends change, procedure rooms may become smaller, a clean core will not be required as procedures become more minimally invasive and all major activities associated with a patient's medical process could be accommodated within the procedure room. As the acuity of surgical cases changes, procedure room sizes will adjust accordingly and this will require the built environment to easily accommodate those shifts.

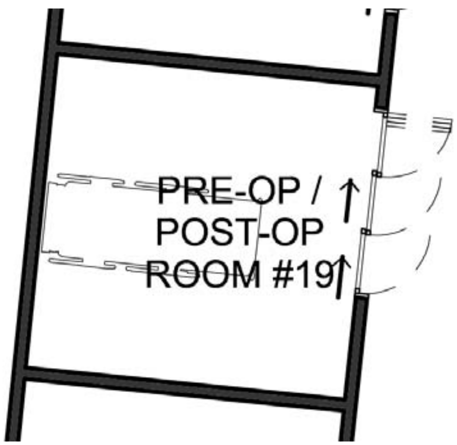


Fig. 56 Plan of a Pre-op and Recovery Room

Pre-op and recovery rooms are the areas of the facility where patients will be prepped for their procedure and where they will return after the procedure to recover. Equipment within these areas includes ancillary instruments associated with marking and preparing the patient for their procedure. This is also where any necessary anesthesia will be administered. The pre-op and recovery areas can become a universal room that is both a pre-op and a recovery room. This will allow for a higher utilization of these spaces. As the number of procedure rooms increases, the pre-op and recovery areas will need to increase in number as well. If procedure rooms become smaller and more universal it could be assumed that a patient could be prepped and then recovery within this one universal room. If this occurred there would be no need for rooms designated exclusively for pre-op and recovery and they would be removed from the program.

Because the adaptable program is intended to change over time just one space list is not sufficient to design the facility for change. The functional program has specifically been considered to accommodate for the adaptation of the physical environment by developing multiple programs of possible case scenarios.

Scenario A: The first potential scenario is the need for the facility to respond to intense high acuity surgery. The adaptable space is programmed to allow for a Class C surgical environment, in which major surgery occurs. This is surgery that requires general or block anesthesia that supports vital bodily functions. (FGI, 2006) In an orthopedic facility these surgical procedures would mostly include hip replacements and repair. These can be performed in a minimally invasive procedure, however, they still typically require general anesthesia.

The minimum space requirements for a procedure room are 400 square feet. (FGI, 2006) However, this does not allow enough space to meet standard clearances and at the same time implement some forms of robotics within the procedure rooms. For example, if the Da Vinci Robot was to be used in the procedure rooms, the square footage of the room would need to be larger to accommodate the surgeons console and other equipment associated with the robot. Since the guidelines are meant to provide designers with minimum dimensions, they do not represent the best practices standards for all areas. Thus, in scenario A, procedure rooms have been designed to be an average of 575 square feet. This is to accommodate for current technological needs and to meet better practice standards. However, because of this there are less procedure rooms, meaning the facility will accommodate a lower volume of high acuity patients. It also requires all other support areas, such as exam, diagnostic, pre-op and recovery rooms to be present in the program.

Potential Scenario A	# of Rooms	Unit Area	Total Area
Diagnositic / Procedure and Exam Rooms			
Exam Rooms	8	177 SF	1416 SF
Procedure Rooms	8	576 SF	4608 SF
Pre-Op / Post-Op Room	20	133 SF	2660 SF
Orthone MRI	4	105 SF	420 SF
MRI Garden	1	799 SF	799 SF
Patient Toilet	4	66 SF	264 SF
Total			**10167 SF**
Staff Areas			
Nurse / Tech Work Rooms	2	149 SF	298 SF
Tech Work Station	2	52 SF	104 SF
MRI IT Room	1	70 SF	70 SF
Control Room	1	1016 SF	1016 SF
Staff Copy Room	1	181 SF	181 SF
RN/Tech Workroom	1	241 SF	241 SF
Family Waiting Area	1	446 SF	446 SF
Nurse Stations	3	439 SF	1317 SF
Staff Toilet	2	80 SF	160 SF
Staff Break Room	1	150 SF	150 SF
Total			**3983 SF**
Support Spaces			
Pharmacy	1	111 SF	111 SF
Equipment Storage	2	139 SF	278 SF
Decontamination Room	1	82 SF	82 SF
Sub-sterile / Scope Wash	1	91 SF	91 SF
Soiled Utility	2	180 SF	360 SF
Soiled Holding	1	150 SF	150 SF
Clean Utility	3	248 SF	744 SF
Housekeeping Closet	1	58 SF	58 SF
Storage	3	321 SF	963 SF
Family Restroom	1	87 SF	87 SF
Total			**2924 SF**
Net Area			**17,074 SF**
Gross Area			**29840 SF**
Net to Gross (multiplier)			**1.75**

Fig. 57 Space List of Scenario A

Scenario 2: The second potential condition scenario is the facility's programmatic response to technological advancements that create a greater need for less invasive surgical procedures. This scenario was designed for Class B surgical procedures, or minor and major procedures with oral, parenteral, or IV sedation or under analgesic or dissociative drugs. (FGI, 2006) The minimum space requirements for each procedure room is 250 square feet, however, this is the minimum and to better meet the varying needs of each procedure, the rooms have been designed to 320 square feet. (FGI, 2006) Because of the reduced square footage from the 575 square feet of the high acuity procedure rooms, the facility will be able to accommodate a larger number of procedures rooms. This also means there will need to be an increase in the number of pre-op and recovery rooms. Because of the reduced square footage of the procedure rooms, they can now be accommodated for on the same floor as the pre-op and recovery areas.

Potential Scenario B	# of Rooms	Unit Area	Total Area
Diagnositic / Procedure and Exam Rooms			
Procedure Rooms	14	320 SF	4480 SF
Pre-Op / Post-Op Rooms	24	144 SF	3456 SF
Exam Rooms	8	177 SF	1416 SF
Orthone MRI	4	105 SF	420 SF
MRI Garden	1	799 SF	799 SF
Housekeeping Closet	2	58 SF	116 SF
MRI IT Room	1	90 SF	90 SF
Total			**10777 SF**
Staff Spaces			
Nurse Station	2	299 SF	598 SF
Staff Copy Room	1	181 SF	181 SF
RN/Tech Workroom	1	220 SF	220 SF
Tech Work Station	2	60 SF	120 SF
Staff Toilet	1	58 SF	58 SF
Total			**1177 SF**
Support Spaces			
Family Waiting Area	2	446 SF	892 SF
Family Restroom	2	87 SF	174 SF
MRI Garden	1	799 SF	799 SF
Patient Toilets	4	80 SF	320 SF
Pharmacy	2	176 SF	352 SF
Soiled Utility	3	90 SF	270 SF
Clean Utility	3	88 SF	264 SF
Soiled Holding	1	128 SF	128 SF
Decontamination Room	2	95 SF	190 SF
Sub-sterile Scope Wash	2	120 SF	240 SF
Storage	5	362 SF	1810 SF
Total			**5439 SF**
Net Area			**17,393 SF**
Gross Area			**29,840 SF**
Net to Gross (multiplier)			**1.72**

Fig. 58 Space List of Scenario B

Scenario 3: The third potential condition is the need to accommodate for varied levels of acuity in a single pre-op, procedure and recovery room. Possible advances in technology could result in a new thought trend on the delivery of care for orthopedics and the program would need to respond by creating a more universal patient procedure room. A new patient experience would emerge, allowing all services to be performed in one room and the programmatic needs of the facility would shift. There would no longer be a need for pre-operation, procedure and post-operation rooms. They could all occur within the same room. This would ease stress on the patients and streamline the staff workflow.

To design for this level of care a scenario was derived based on the needs of Class A surgery or minor procedures performed under topical, local, or regional anesthesia without pre-operative sedation. This calls for minimum space requirements of 120 square feet per room, however, this is the minimum requirement for a procedure room alone. (FGI, 2006) Since these rooms will be more universal and will include more activities, such as pre-op, diagnosis and recovery as well as the actual procedure, a 260 square foot room was used instead.

Potential Scenario C	# of Rooms	Unit Area	Total Area
Diagnosis / Procedure and Exam Rooms			
Exam / Procedure Rooms	30	260 SF	7800 SF
Tech Work / Observation Areas	12	113 SF	1356 SF
Tech Work Area	6	50 SF	300 SF
Exam Rooms	9	144 SF	1296 SF
Orthone IT / Print Room	3	136 SF	408 SF
Orthone MRI	3	97 SF	291 SF
Total			**11451 SF**
Staff Areas			
Staff Lounge / Break Room	3	250 SF	750 SF
Nurse / Tech Work Area	3	293 SF	879 SF
Total			**1629 SF**
Support Spaces			
Pharmacy	3	156 SF	468 SF
Storage	3	500 SF	1500 SF
Storage	3	227 SF	681 SF
Equipment Alcove	3	70 SF	210 SF
Wheelchair Alcove	3	42 SF	126 SF
Clean Utility	3	190 SF	570 SF
Soiled Utility	3	181 SF	543 SF
Equipment Alcove	3	38 SF	114 SF
Patient Toilet	3	80 SF	240 SF
Total			**4452 SF**
Net Area			**17,532 SF**
Gross Area			**29,840 SF**
Net to Gross (multiplier)			**1.70**

Fig. 59 Space List of Scenario C

Net to Gross Comparison: It is important to note the changes in the net area to the overall gross area of the adaptable scenarios. The results show that as the acuity levels dropped and the rooms became more universal that the net to gross decreased as well, providing a more efficient floor plan. The net to gross comparison for each scenario decreases as the procedures rooms decrease in size, but increase in number.

Potential Scenario A	
Net Area	17,074 SF
Gross Area	29840 SF
Net to Gross (multiplier)	1.75
Potential Scenario B	
Net Area	17,393 SF
Gross Area	29,840 SF
Net to Gross (multiplier)	1.72
Potential Scenario C	
Net Area	17,532 SF
Gross Area	29,840 SF
Net to Gross (multiplier)	1.70

Fig. 60 Net to Gross Comparison of Adaptable Scenarios

If the program provides for multiple potential futures, then it should be more adequately prepared to transform itself as it changes due to technological and patient practice changes.

SITE OF ADAPTABILITY

The site selection for an out-patient orthopedic surgery and rehabilitation facility was determined and based on a set of specific site criteria. These criteria will also be used to determine the appropriate site for the architectural representation of adaptive customization.

Site Selection Criteria

The rationale for choosing a location for the proposed program was established based on a regional demand for an out-patient orthopedic facility, a logical location for a site, the availability of a site and access to an adequate transportation infrastructure for easy access to it. The facility should have convenient access for patients traveling from a reasonable distance. The project would benefit from being located near, or adjacent to, complimentary healthcare services and settings. The project would benefit from being located in an active city with a diverse population who has an identified need for orthopedic services. The site should also be considered an international destination that can serve a broad range of athletes and other professionals from beyond the bay area. The site should be able to successfully accommodate the proposed out-patient orthopedic facility’s current and changing programmatic needs over time. The facility would ideally be set in an area that has room to grow and expand through adaptive customization at the building and site scale.

Active City: The site for an out-patient orthopedic surgical and rehabilitation facility should ideally be located where it can serve a large active and athletic population. The patient population of orthopedics spans multiple generations and affects a broad range of diverse individuals. An active population will provide a good market base for orthopedic care.

International Destination: A world class out-patient orthopedic surgical and rehabilitation facility will provide care for a high volume of athletes. Many of these athletes may be professionals and Olympians and will be attracted to places that are international destinations and well known worldwide. Locating is such a place will be more attractive to professional athletes who are willing and able to travel for the best care possible.

Regional Demand: The proposed project site should have a strong regional demand for an out-patient orthopedic surgical and rehabilitation facility as well. There must be a definitive market and need for orthopedic care in the area. It is also important to locate near surrounding facilities serving orthopedic patients and providing similar care.

Proper Transportation Infrastructure: The site should be easily accessible to major vehicular and public transportation routes, which allows convenient access to the facility for patients, family, and staff. The site should also be easily accessed from a major airport for patients traveling from greater distances. The specific site selection should consider is the need for easy way finding to the facility and an accommodating and gracious patient drop off and parking process. Orthopedic patients will need more time entering and exiting the facility because they may be physically limited. They may need assistance in some way if they are elderly, are in a wheelchair or are using crutches. A drop off area that allows for an easy and stress free curb side arrival would be more ideal for patients arriving and leaving the facility.

Complimentary Healthcare Services: It would be advantageous if the proposed out-patient orthopedic surgical and rehabilitation facility was located near or associated with a larger medical center. Because the facility will be performing relatively high acuity surgical procedures on an out-patient basis, it would be beneficially to have immediate access for patients and physicians to be near an in-patient facility when needed for more complex inpatient surgical and diagnostic services. If something happened during an out-patient surgery that would cause the patient to need to be admitted to an in-patient facility, close proximity to a medical center would be advantageous.

Allow for Adaptive Customization: It is paramount that the site for the proposed facility be able to accommodate and allow for adaptive customization. This means that the site needs to have the ability and the flexibility to grow and expand over time. It would be impossible to study the architectural implications of adaptive customization at the site and building scales, simultaneously, if the site was completely restricted.

Site Selection

The site was chosen based on the criteria established for an out-patient orthopedic surgical and rehabilitation facility. It was also selected based on its ability to meet the needs of adaptability and assist in a design and exploration on the architectural implementation of adaptive customization.

Context Selection: After having determined the importance and need for the specific site selection criteria, the city of San Francisco was chosen based on its compliance and fulfillment of those conditions. San Francisco is an active city. It consistently ranks in the top five most healthy and active cities in the United States. (SFCED, 2) The bay area consists of a large population of individuals who do an excellent job maintaining a high physical activity level. The city is also home to over five major sports teams and a wide variety of amateur sports teams. San Francisco provides an active population and is a good market sector for an out-patient orthopedic care facility.

San Francisco is an international destination that is able to serve a broad range of athletes and other professionals. An out-patient orthopedic surgical and rehabilitation facility will more adequately provide care for athletes when it is located in an easily accessible city. San Francisco International Airport has been ranked as the number one airport in North America for four consecutive years. (SFCED, 4) SFO Airport is well equipped with easy access to public transit, ground transportation and major highway systems. This makes it easy to navigate into the city from the airport.

Fig. 61 Diagram of the city of San Francisco and pertinent information relative to site criteria

There should be a regional demand for an out-patient orthopedic surgical and rehabilitation facility within the San Francisco Bay Area. To establish the most appropriate area, the city was analyzed to show highways, fault lines, sports complexes, orthopedic clinics, medical centers and parks relative to the site criteria. There must be a market and need for orthopedic care in the chosen area and facilities providing similar care should be identified within the city.

Site: The Mission Bay area of San Francisco was selected based on its relative location to other orthopedic facilities and the stated need for additional orthopedic care in the region. There is a stated need for orthopedic care near the new University of California, San Francisco Medical Center to be located in Mission Bay. Currently no orthopedic facility exists in this area. "In fact, the unrelenting demand for orthopedic surgeons and other specialists has put an extraordinary amount of pressure to recruit and retain the best in their field." (UCSF, 3) This demand is driven by the large volume of patients San Francisco General Hospital treats that are inflicted with fractures. (UCSF, 3)

Fig. 62 Selected site in Mission Bay of San Francisco

The site should provide relative association or proximity to complimentary healthcare services. Within the area of Mission Bay, there is major medically related growth and development consisting of a new UCSF research campus containing 2.65 million sq. ft. of building space on 43 acres of land. There is also a proposal for a 550 bed hospital that would be part of the new University of California campus in Mission Bay. The new University of California has submitted a proposal for a 550 bed hospital and ambulatory care services that

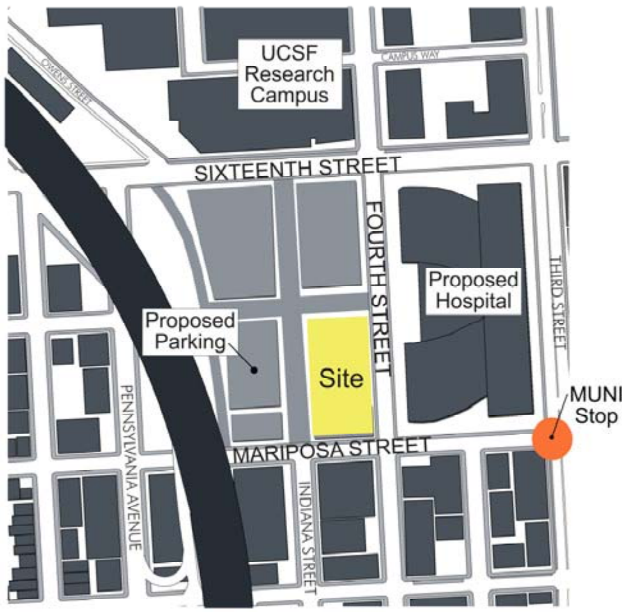


Fig. 63 Selected Site and Surrounding Area

are to include orthopedic care. This makes the new UCSF Mission Bay campus an ideal location for an out-patient orthopedic facility.

The selected Mission Bay site is located on the corners of Fourth Street and Mariposa Street, adjacent to the new UCSF Medical Campus. It is also highly accessible from almost all forms of public transit and vehicular transportation within the city. This allows convenient access to the site for patients, family, and staff. The site is located two blocks from public transit route of MUNI which stops on Third Street. MUNI [the San Francisco Municipal Railway] is an integral part of public transit throughout the San Francisco Bay Area. It operates 365 days a year and connects with other regional transit services such as the Bay Area Rapid Transit or BART. This makes it possible for someone to ride BART from the SFO Airport and then connect to a MUNI line and stop two blocks from the proposed site. The site is also located approximately half a mile from the major terminal of Caltrain, a commuter rail line operated by Amtrak. Trains operate out of San Francisco and San Jose every half hour on weekdays. This makes it possible for patients living outside the immediate Bay area to easily travel into the city to receive care. The site is also located one block from the exit ramp of a major vehicular artery, Route 280. And because the site is also

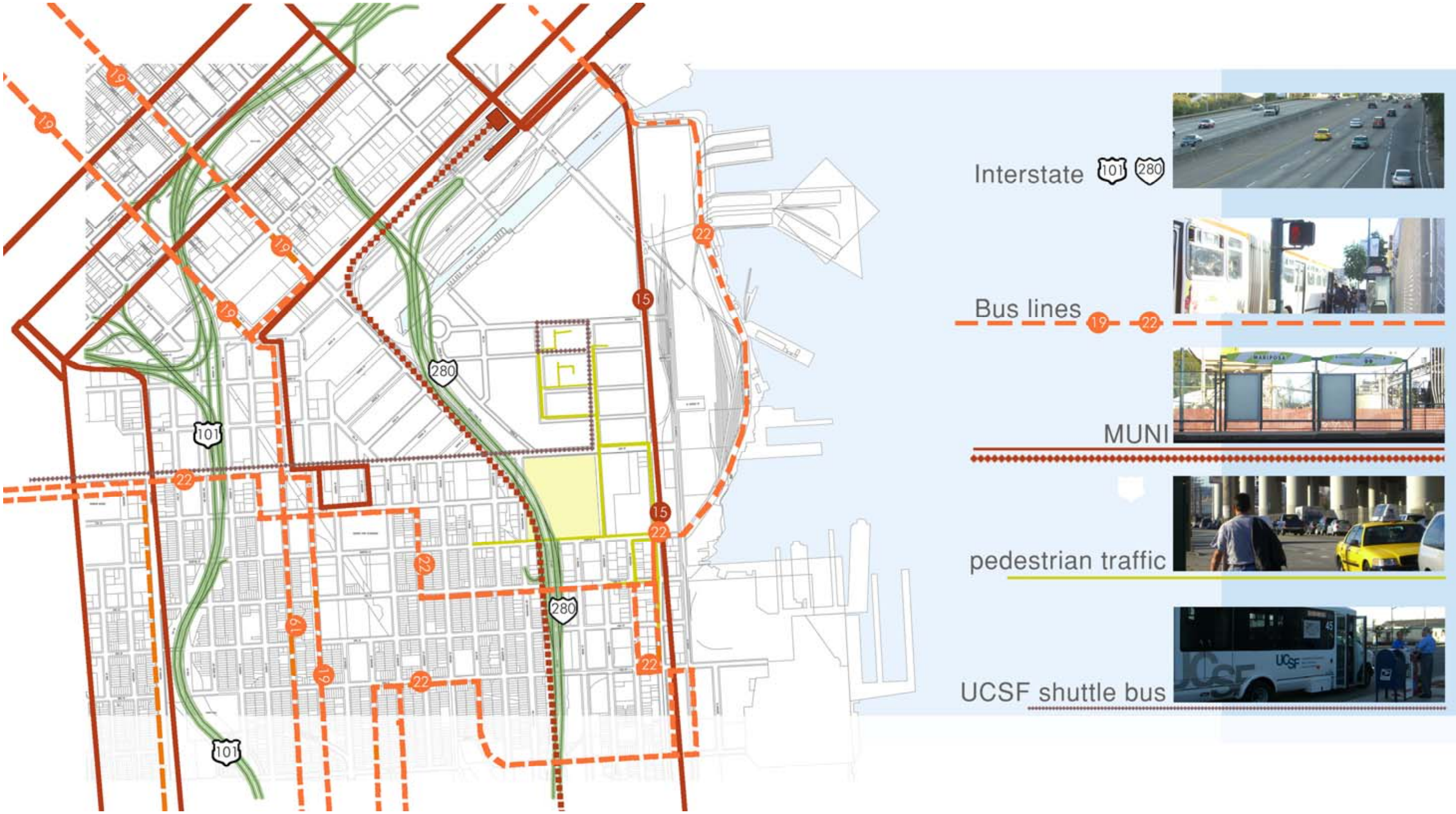


Fig. 64 Mission Bay Transportation Routes, stops denoted with dots

located adjacent to a proposed parking garage, access for patients traveling by car would be convenient, straightforward and uncomplicated.

It is important to note that the proposed parking garage is located off of the future extension of Indiana Street and this will be a less trafficked road. It can easily be designated as a patient drop off zone. Orthopedic patients will need more time entering and exiting the facility because they may be physically limited and this area will be ideal for patients arriving and leaving the facility.

It is critical that the chosen site within Mission Bay adequately provide for adaptability. The Mission Bay area in San Francisco is the largest area within the city currently under development. The urban development plan for Mission Bay is extensive and includes, but is not limited to 6,000 housing units, 6 million sq. ft. of office/life science/technology and commercial space. The proposed site is located adjacent to the proposed UCSF hospital and near the new UCSF research campus. This means the chosen site is currently under-developed and there is great potential that the planned site development will allow for expansion over time. Since the site is in an area of significant future transformation it is an ideal candidate to explore adaptive customization because it must be organized in a way that will allow an adaptable response to changing site context conditions. It is also not overly constrained by surrounding buildings now, however it will be in a constant state of change for the foreseeable future as the hospital is constructed, parking is added and new programmed building are constructed overtime. If a plan for adaptability of the site can be designed before all construction occurs, the appropriate infrastructure can be maintained at the site level to allow for change.

Site Opportunities: It is important to note the surrounding area and any pertinent contextual information, and then locate potential site opportunities. The selected site in the Mission Bay area has very desirable views to the downtown skyline as well as views to the bay. These are positive attributes of the site that could influence the design of the facility. The accessible views are positive because they can enhance the overall experience of the facility.

Fig. 65 Desirable Views from the Site

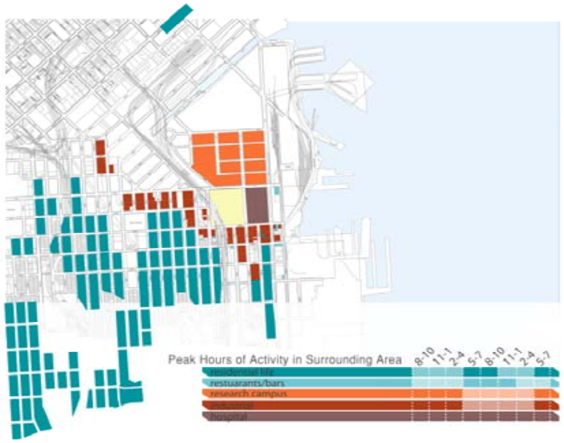


Fig.66 Mission Bay Zoning

Noting the significant surround activities of the site and the peak hours of those activities will help in designing the correct location and orientation of the facility. Mission Bay zoning consists of residential areas, industrial zones and commercial buildings. It also includes the proposed hospital and UCSF campus site. The design proposal may be influenced by understanding the peak hours of activity in the surrounding area. This will help determine which streets to designate as commercial or where the best location to gain access into the site would be located.

Fig. 67 Surround Site Activity

Site Constraints: The constraints to the chosen site are set forth by the planning department of the city and county of San Francisco, California. Part IV, the purpose of the Mission Bay district, section 930, sets the establishment and limitations of height in Mission Bay Districts. It states the height restrictions as 65'-0". Section 933, states the exemptions from height limits for mechanical equipment, elevators, stairs and mechanical penthouses. This exemption is limited to 16 feet for such features. According to section 943, rooftop features shall be enclosed and screened in such a manner that the enclosure is designed as a logical extension of the building form and an integral part of the overall building design. It must be a rooftop form which is appropriate to the nature and proportion of the building, and is designed to obscure silhouette for the top of the building. These restrictions require the building to be no more than five floors however mechanical penthouses can extend beyond these limitations as stated.

The site should also maintain consistent setback dimensions with the surrounding area and neighboring blocks. This will result in full utilization of the site and setbacks from the street and sidewalks will be minimal.

The location in Mission Bay was selected because of its availability, the existing and ability for future circulation routes, the stated need for an orthopedic clinic in the area and its ability to adhere to other site criteria. Satisfying all stated criteria, the site increases the programs ability to investigate varying forms of adaptive customization and presents little to no limitations for its exploration. This is because the site has not yet been developed. It can be developed to allow for adaptability overtime by appropriately locating roads through the site and planning for future growth it will achieve a higher level of adaptability overall. For example, if the future parking garage is located in an area that it could easily be connected to future buildings or could be taken over as a programmed space this would allow for change and adaptability over time. Planning future expansion and development of the site in the early stages of its development will allow for adaptability at the site scale.

Fig. 68 Selected Site and Surrounding Area

The design proposal for an out-patient orthopedic surgery and rehabilitation facility is based on the design principles established to achieve a form of architectural adaptive customization. The proposal seeks to improve the patient experience and provide adaptability for future growth and medical technologies. The overriding design concepts developed from the site organization, then to the building form and its massing. From there the prevailing building organization and experiential qualities of the design developed.

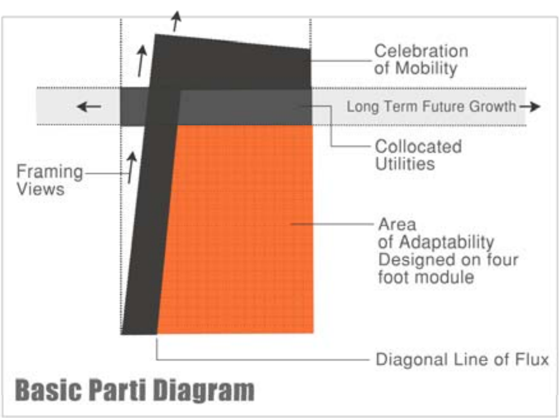


Fig. 69 Building Parti Diagram

The basic parti diagram for the facility was developed according to the principles established for adaptive customization. A vertical co-location, or stacking, of utilities were located to service the entire building and strategically placed to allow for long-term future growth throughout the overall site. Once the location for this service element was establish, the adaptable area was located to provide the largest amount of open floor area. The location of the service element and the adaptable area left views to the city visible from public areas of the building. To further define and frame these views, the lobby space was tapered to open toward them. The basic parti was developed from analyzing the surrounding blocks and organizing the building so that growth over time could occur more easily at the site and building scale.

Fig. 70 Proposed Road Additions, Mending of Urban Grid

Fig. 71 Proposed Road Additions in Orange

Site and Context Adaptability

The site development and organization resulted from the need to break down the large urban block that existed. The urban grid was extended into larger building site to better relate to the size of the surrounding blocks, improve accessing into and around the site and to create a more humane walk able urban district. The extension of Indiana Street as well as the addition of a road parallel to Mariposa Street achieved a finer urban grain fabric and allows for easier access throughout the site. It also begins to organize a pattern for site development.

The first phase of site development would be the construction of a parking garage to the southwest portion of the site and then the design of the out-patient orthopedic surgery facility to the east of the parking. Future growth for the orthopedic facility could occur over these street extensions to the north portion of the site, or if the need arose, could extend into the site of the parking garage to the west. After having analyzed the transportation routes of the area and the peak hours of activity, it was determined that the block designated for the project should be designed to enliven Mariposa Street with retail space because it could potentially see expanded pedestrian traffic. In addition to increasing pedestrian traffic in the area as a result of new development, residents who live in the surrounding neighborhood would most likely walk down Mariposa Street to catch public transportation on Third Street.

Fig. 72 Patient Drop-off Zone in Orange

Approach to the site for the out-patient orthopedic facility would be via Mariposa Street and then turning onto the Indiana Street extension, with a drop off zone for patients along Indiana Street. Orthopedic patients will need more time entering and exiting the building, due to potential physical limitation. The extension of Indiana Street would service less traffic, making it a more ideal location for the entrance to the facility.

Providing the Infrastructure for Adaptability

To allow for adaptability of programmatic and technological changes associated with the merging of imaging and surgery, the necessary architectural infrastructure must be provided.

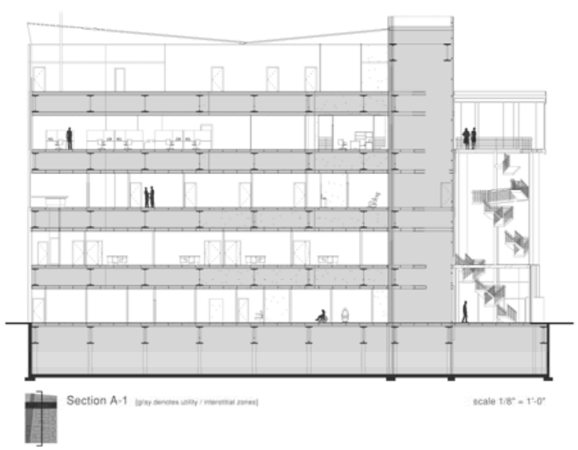


Fig. 73 Long Section Highlighting Interstitial Space and Access from Co-located Utility Bar

Co-location of Utilities: To allow for adaptability throughout the building, a large amount of infrastructure has been provided. Five foot high accessible interstitial space has been assigned between each floor. The co-location of all building wide services and utilities occurs in a larger vertical service element that feeds and provides access to the interstitial space. These interstitial floors and the utilities bar provide access throughout the facility to service and change systems and technologies. The procedure, diagnostic, pre-op and recovery floors will need the most flexibility overtime as technology changes and so providing access up and down into these areas from the interstitial space will allow for ease in transition of technologies and equipment. To allow for additional flexibility the floor has been raised above and the ceiling dropped below the floor/ceiling structure on each floor and set in a four foot module. This gives the opportunity to easily supply data and to create a unique ceiling condition when desired.

Fig. 74 Co-location of Utilities as Distinct Design Element

Exterior Wall and Façade Conditions: The vertical mechanical zone of utilities is expressed as a distinct design element. The mechanical systems will all be located within this bar of space because these systems may all need to address the exterior wall with different conditions, such as a variety of vents. This exterior condition will consists of a double skin that has a screened element between the vents and the exterior façade of the building. The outer perforated metal skin hides any unsightly elements and allows the systems to move and shift on the exterior wall without affecting the overall visual quality of the building. LCD lights could be placed in-between the wall and the screening element. This would permit this vertical utilities element to change colors at night, giving new and varied life to the building.

It is most critical that the building envelope also be dynamic at the exterior walls of the designated adaptable areas of the facility that must be able to accommodate changes in

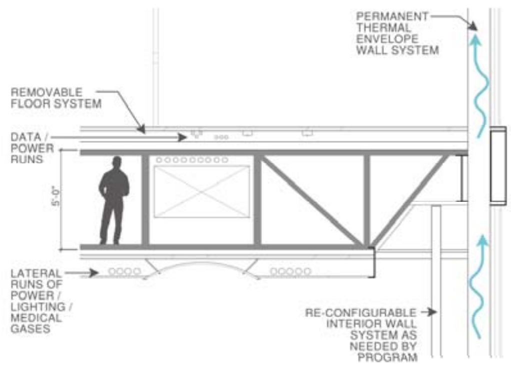


Fig. 75 Interstitial Space Detail

programmatic needs. Walls will meet the exterior of the building in different areas as rooms and interior spaces change and the façade needs to allow for these varying conditions. The exterior wall of this portion of the building is designed as a thermal envelope double wall system. This double wall system is essential so that the exterior façade of the building does not inhibit internal change and can also respond to external changes. It is also important so the interior can be modified, without disrupting the overall exterior visual order of the building. The glass curtain wall can be left exposed on the interior or a re-configurable interior wall can be added as needed by the program.

Fig. 76 Overall Building Form, Showing Wrapping of Interstitial Spaces

The exterior façade of the building is meant to serve as a physical manifestation of the design principles of adaptive customization. The interstitial spaces are highlighted by large bands of insulated metal clad panels on the exterior of the building. This is designed to express the functions of the served and service spaces, without directly articulating specific interior program needs on the exterior façade. This provides a consistent rhythm to the building form, but allows the functional spaces between these bands to change and adapt without disrupting the overall building form.

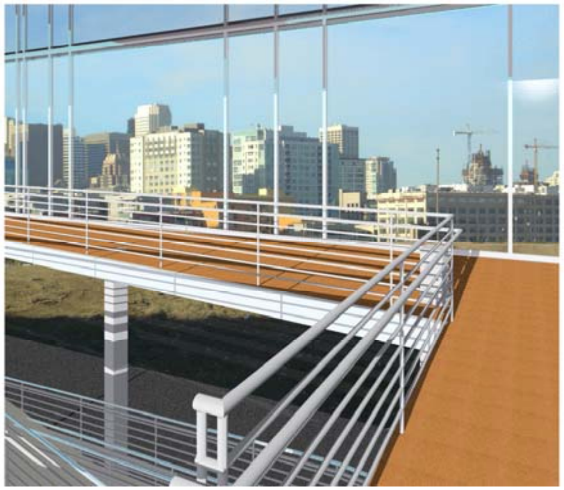


Fig. 77 Framed Views from the Ramp

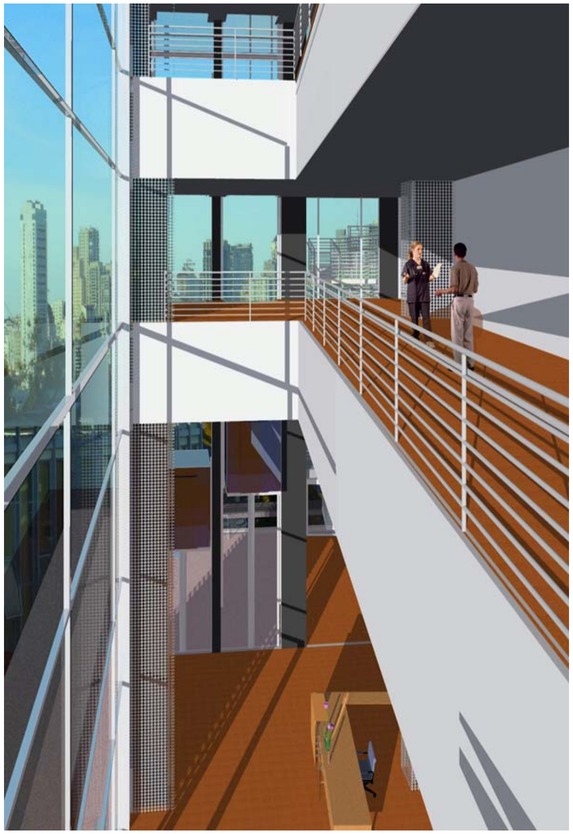


Fig. 78 Framed Views to City

Providing a Positive Patient Experience

To react to the higher expectations of the patient population of orthopedics, the project explored how to create a positive more dynamic patient healthcare experience. Several areas of focus included capturing of desirable views, creating a unique experience through varied modes of mobility, the diagnostic Orthone MRI rooms, and a textural garden,. These areas developed out of the design process and strived to improve and create a better patient experience.

Capturing Desirable Views and Creating Unique Experiences: Views to the city and bay were captured through the use of accessible forms of circulation. These design features are designed to assist and to provide incentives to patients in their rehabilitation efforts by providing forms of positive therapeutic distraction for patients experiencing discomfort. The ramp in the lobby area of the building and the glass elevators were designed to allow all users to freely navigate the building and not feel intimidated or confronted by spaces that limit

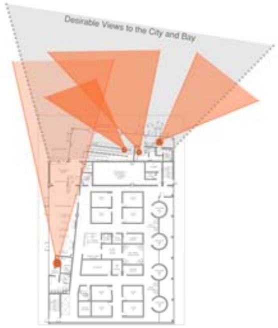


Fig. 79 Framed Views to the City

their functioning or movement. This provides rewarding visual stimulation for patients, but also provides the same visual and physical experience for all visitors.

Fig. 80 Entrance Experience

The entrance is located adjacent to the glass elevators and a large accessible ramp. This is intended to ease patients concerns about navigating the building. These elements seek to help create a non-threatening building for people with limited abilities and ranges of motion. There is also a visual link from the waiting area to the elevators and ramp. This connection provides views to movement activity within the building for, and of, visitors and patients.

The elevators and the ramp are also used to help frame and provide access to desirable views to the city and the bay from the site. These views can also be seen from the family wait rooms on the second and third floors, within the elevator cabs, in the elevator lobbies, and the ramp. These views intend to provide a more desirable and interesting patient experience.

Fig. 81 Lobby

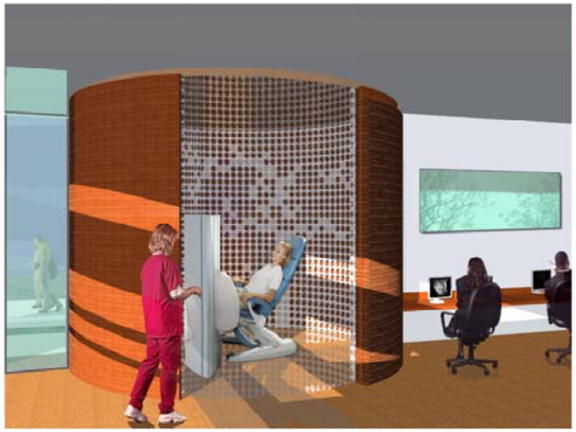


Fig. 82 Orthone MRI Experience


Fig. 83 Orthone MRI areas set within serene texture garden

Orthone MRI: The Orthone MRI diagnostic rooms are treated as sculptural elements set in a serene garden. This highlights the unique elements of the MRI while providing a calming environment to patients and staff. This is achieved by placing the diagnostic rooms close to the exterior façade, allowing a connection to light and nature.

The Orthone MRI employed in this proposal is a comfortable non-threatening, non-claustrophobic MRI device that creates scans with extremely high quality images. A truly open MRI system, the scan is dedicated to extremities and performed while sitting in a comfortable chair. All the necessary copper radio frequency shielding has been designed into a circular field. It is intended to be all inclusive and freestanding. The copper shielding required for MRIs, is within the rounded shell and it can be placed in any built environment. This is extremely advantageous to the architectural setting because it does not require shielding of the more permanent walls. In that way, the Orthone MRI is portable and more easily moved from or into a facility. Natural scenes have been abstractly created within the shielding to provide texture to the space and set itself apart from the garden, while still providing privacy to the patients.

Textural Garden: Since the Orthone MRI presents a uniquely shaped space, this is expressed on the exterior of the building. The remaining area has been designed as a textural garden. This provides views from within the diagnostic floor to natural elements. The natural textures are intended to offset the more sterile nature of the medical environment.


Fig. 84 Orthone MRI garden, textures

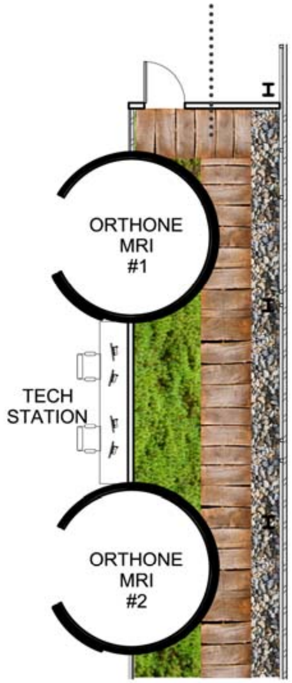


Fig.85 Plan of Orthone MRI area and texture garden

Phasing of Multiple Potential Futures

To better allow for adaptability, phasing plans for multiple potential futures have been established. Having planned and provided the program for three different potential scenarios, it is important to establish where, when and why these scenarios would need to occur.

Phase 1: The first phase of the facility will develop from the original need for an out-patient orthopedic surgical and rehabilitation facility. It includes four large procedure rooms that can accommodate high acuity surgery.

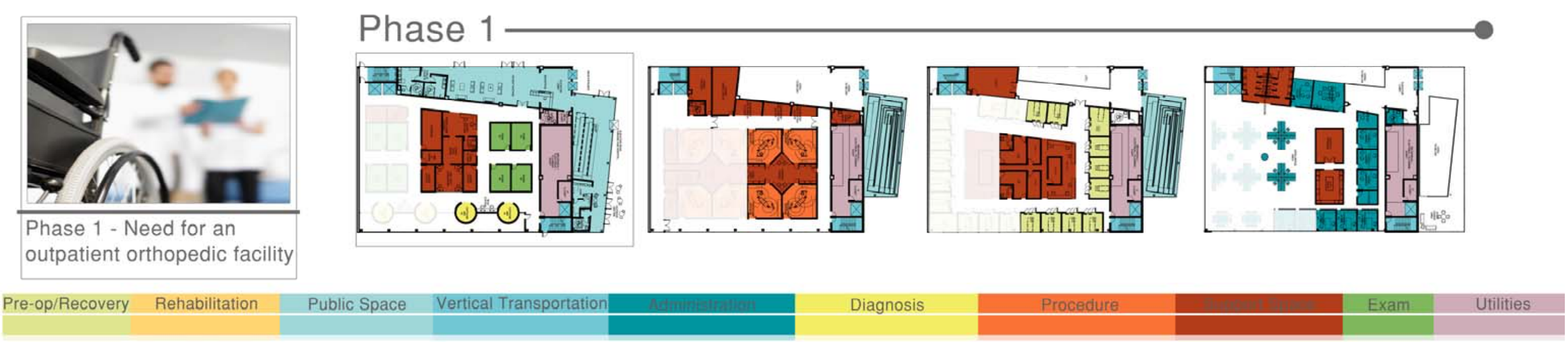


Fig. 86 Phase 1 of Multiple Potential Futures

Phase 2: The second phase for the out-patient orthopedic facility will develop as patient volumes increase and the need for more procedures is evident. This growth will occur on the first three floors as the procedure rooms double in number to eight and the exam, pre-op and recovery areas increase in number of rooms as well. The administration floor expands to occupy the entire fourth floor.

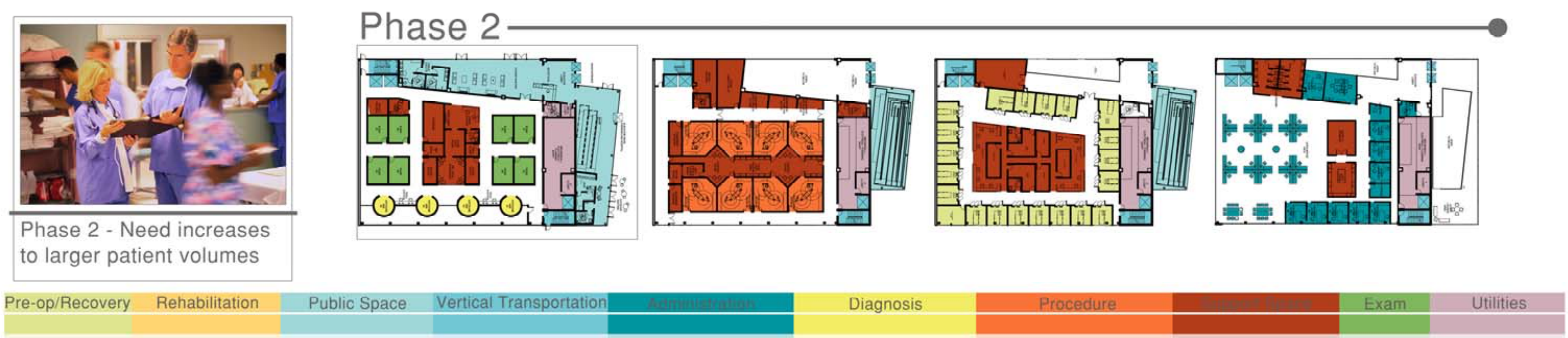


Fig. 87 Phase 2 of Multiple Potential Futures

Phase 3: As technology advances there will be an increase in the number of minimally invasive surgeries that do not require as high of an acuity level, the second floor can be reconfigured to accommodate lower acuity procedure rooms. Since the floors are designed on a four foot module the floor can transform to a new layout with minimum disruptions.

Fig. 88 Phase 3 of Multiple Potential Futures

Phase 4: The original program for the out-patient surgical facility may not include the rehabilitation component. This can be phased in on the top floor as the need for rehabilitation services become necessary. The vertical utilities shaft has an elevator where construction supplies can be brought and supplied to the roof to minimize disruptions during the construction process of the rehabilitation component.

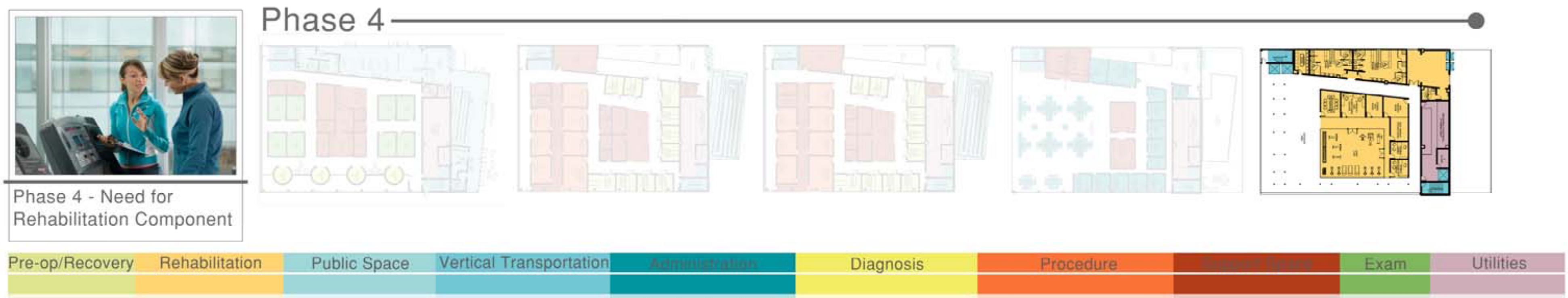


Fig. 89 Phase 4 of Multiple Potential Futures

Phase 5: The fifth phase of the facility will occur when technological and medical practice changes result in the need for more universal procedure rooms. These rooms will be used as diagnostic rooms as well as pre-op and recovery rooms. This will require the reconfiguration of the second floor. The first floor and third floor would remain operational while the adjustments and necessary changes occurred on the second floor.

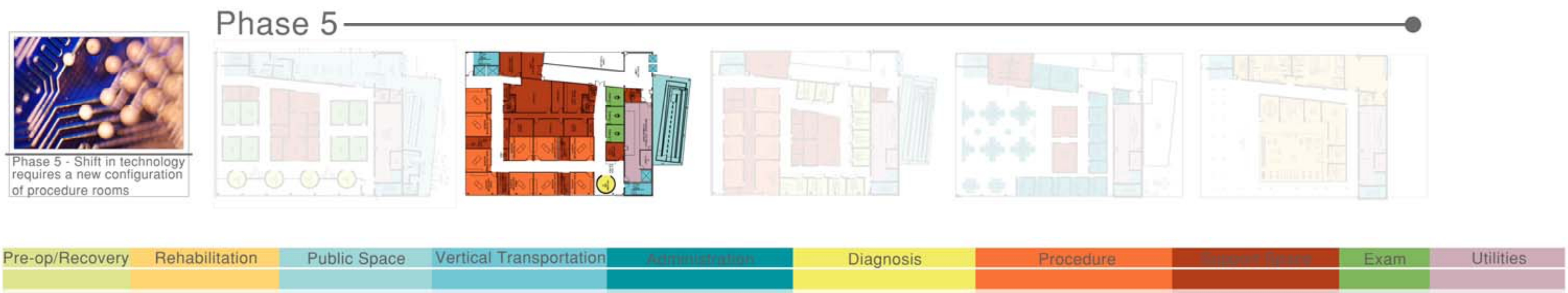


Fig. 90 Phase 5 of Multiple Potential Futures

Phase 6: The sixth phase would result from an increase in patient volumes as well as an increase in more universal procedure rooms. This phase would require the reconfiguration of the first and third floors, resulting in more universal rooms and more uniform floor plates.

Fig. 91 Phase 6 of Multiple Potential Futures

Concluding Remarks

The architectural response of an outpatient orthopedic clinic, one that merges the fields of imaging and surgery, needs to be architecture of changing needs. The architecture needs to provide a more efficient, effective and diverse patient experience through the use of adaptive customization. Adaptive customization, when implemented into the architectural environment through the use of a prescribed set of design principles has the potential to accommodate for more adaptability. A high level of adaptability coupled with the ability to customize each adaption can help create a more unique and improved experience for patients, families and staff.

APPENDIX

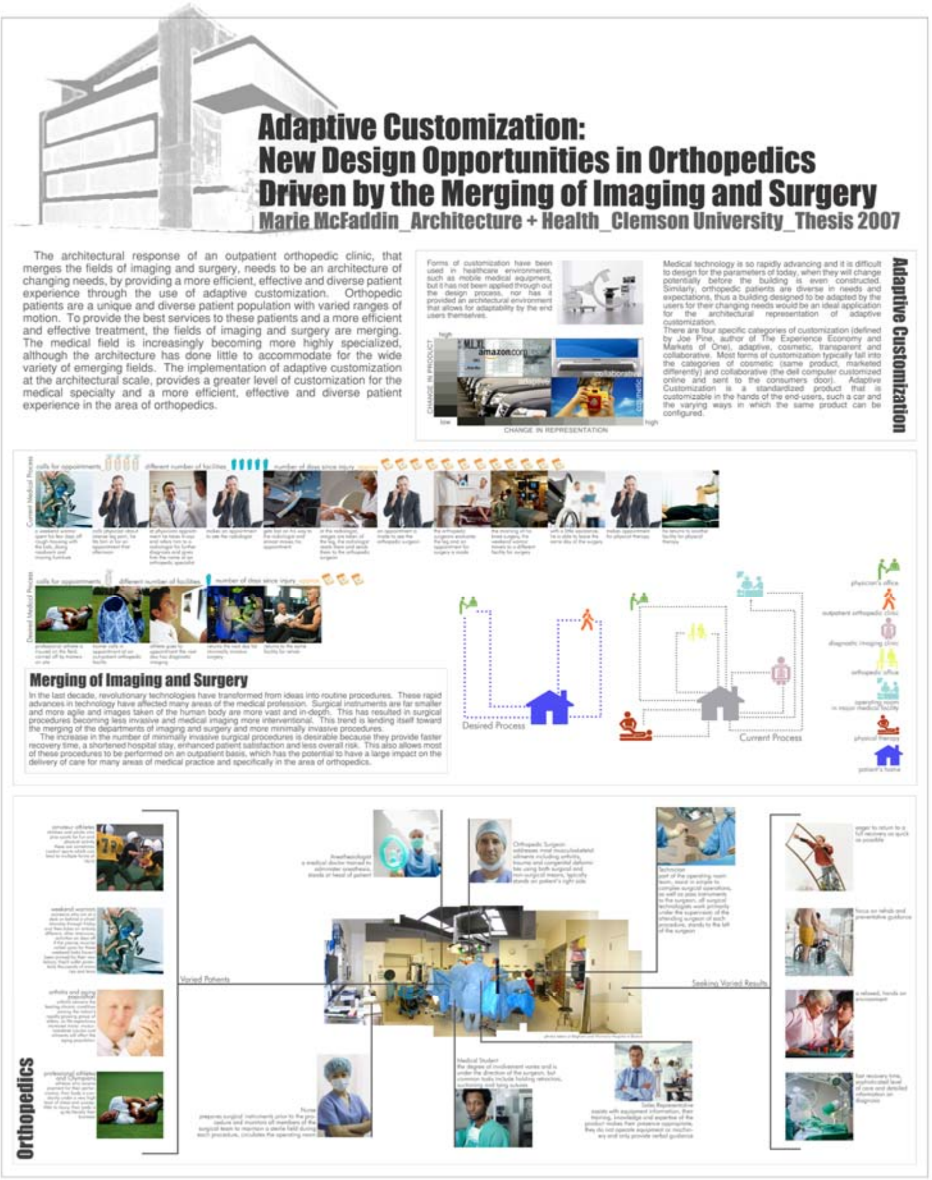


Fig. 92 Research Project Board

Fig. 93 Design Principles Project Board

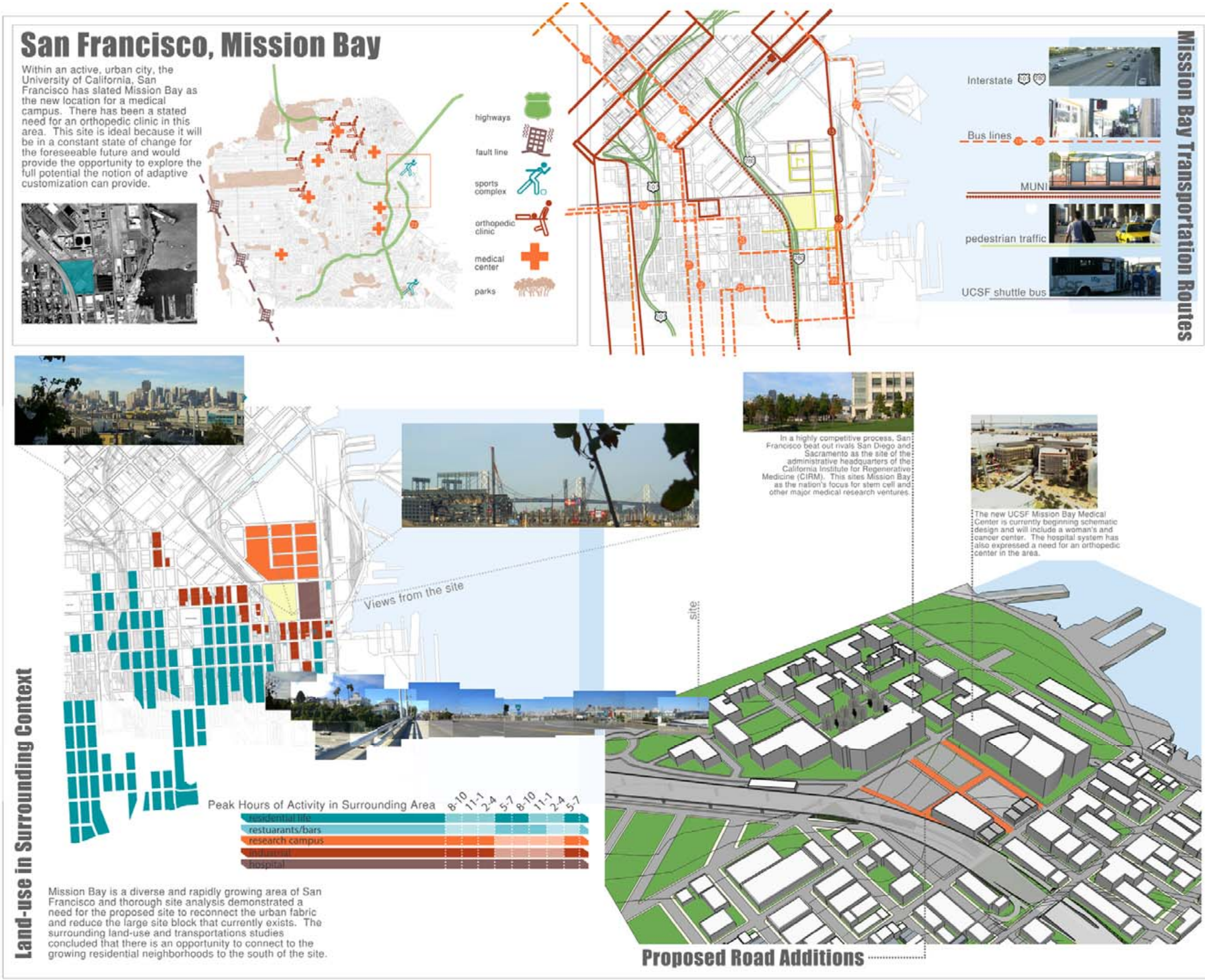
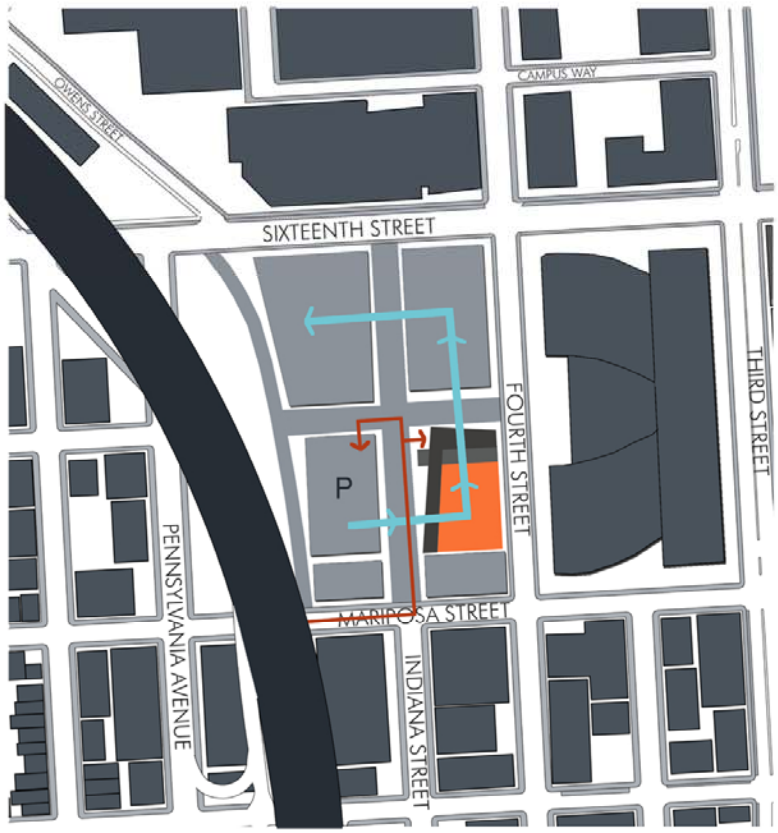


Fig. 94 Site Project Board

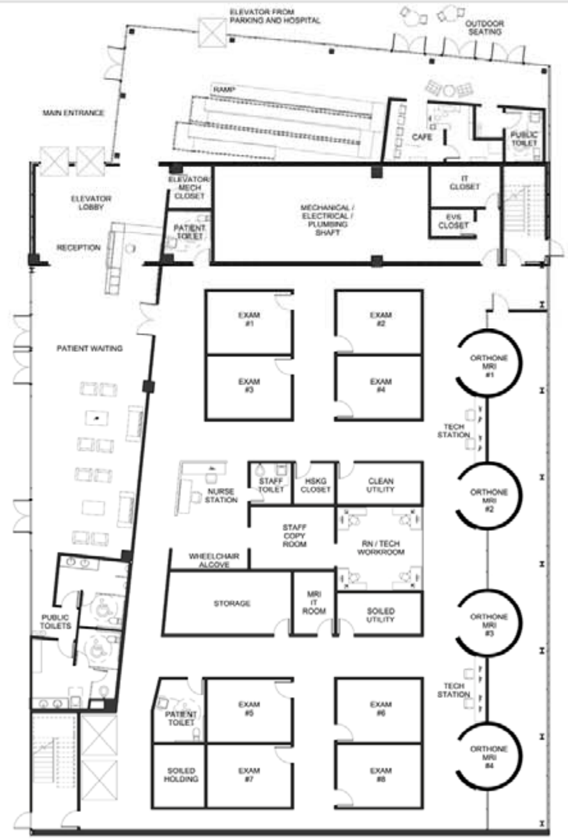


Site

Approach to the site would be from Mariposa Street, with a drop off zone for patients along Indiana Street. The extension of Indiana Avenue would service less traffic, making it a more ideal corner for the entrance of the facility.

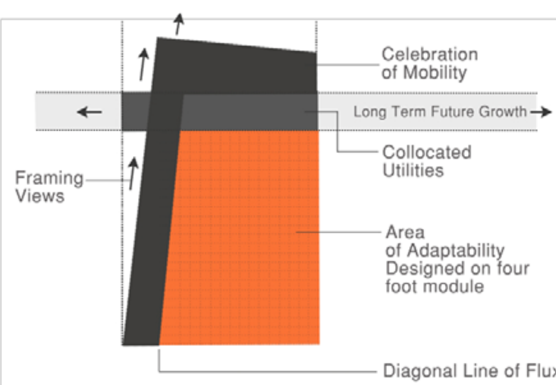
The site growth pattern in blue represents the development over time. The first phase would include a parking structure to service the orthopedic facility as well as the new hospital. Subsequently, the site would develop to the north and then west toward Pennsylvania Avenue.

Photos from the site and surrounding area.



First Floor

scale 1/8" = 1'-0"



Basic Parti Diagram

Fig. 95 Parti Project Board

Second Floor - Procedure Rooms
Potential Condition 1
scale 1/8" = 1'-0"

Third Floor - Pre-op and Recovery
Potential Condition 1
scale 1/8" = 1'-0"

Potential Condition 1

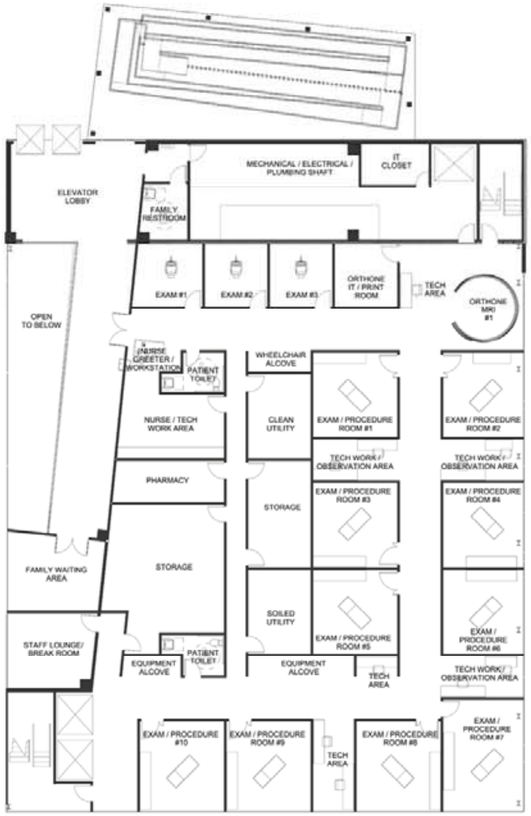
Operating Room, Brigham and Women's Hospital, McFaddin 2006

Reacting to a Need for High Acuity Surgery

The need for the facility to respond to intense high acuity surgery is a possibility. The adaptable space is designed to allow for a Class C surgical environment, in which major surgery occurs. This is surgery that requires general or regional block anesthesia that supports vital bodily functions. The minimum space requirements as stated by the Guidelines for Design and Construction of Hospital and Health Care Facilities, for the procedure room is 400 square feet, an 18 foot minimum dimension and a four foot clearance around the operating table.

In a vertical response to theses needs, the procedure rooms, which would require a redline condition or a clean restricted area, are placed on the second floor. The pro-operation and post-operation rooms are on the third floor and allow visibility from the nurse stations. The floor is designed to give the ability for a pre-op room to become a post-op room through out a day of surgery.

Fig. 96 Potential Condition Project Board 1



Exam / Procedure / Recovery - same room scale 1/8" = 1'-0"
Potential Condition 2

Pre-op / Recovery and Procedure - same floor scale 1/8" = 1'-0"
Potential Condition 3

Potential Condition 2

Technological Advancements

Possible advances in technology could result in a new thought trend on the delivery of care for orthopedics. A new patient experience would emerge, allowing all services to be performed in one room. This would ease stress on the patients and streamline the staff workflow. To design for this level of care a scenario was derived from the Guidelines for Design and Construction of Health Care Facilities based on the needs of Class A surgery or minor procedures performed under topical, local, or regional anesthesia without preoperative sedation. This calls for minimum space requirements of 120 square feet per room, with a 10 foot minimum dimension and three feet clear around the procedure table.

Potential Condition 3

Accommodating for Varied Levels of Acuity

The facilities patient demand could range in need from minor to major procedures. The architectural response can accommodate for a combined approach to the acuity levels of surgical procedures. The procedure rooms are on the same floor as pre-op and post-op rooms. This also allows the facility to double their volume of patients. This scenario was designed for Class B surgical procedures, or minor and major procedures with oral, parenteral, or IV sedation or under analgesic or dissociative drugs. The minimum space requirements are 250 square feet for procedure rooms with a minimum dimension of 15 feet and three feet clear around the operating table.

Fig. 97 Potential Condition Project Board 2

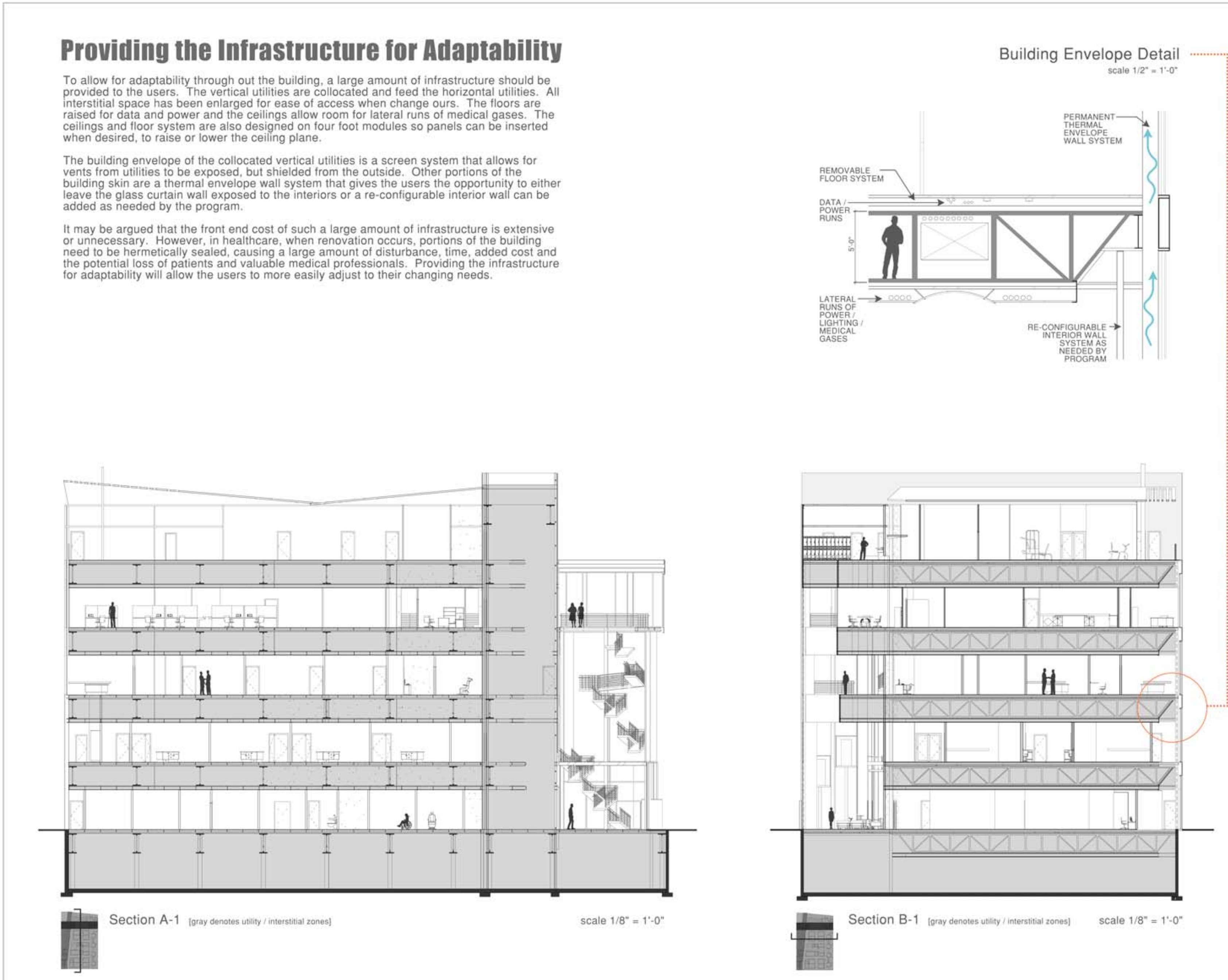


Fig. 98 Details and Sections Project Board

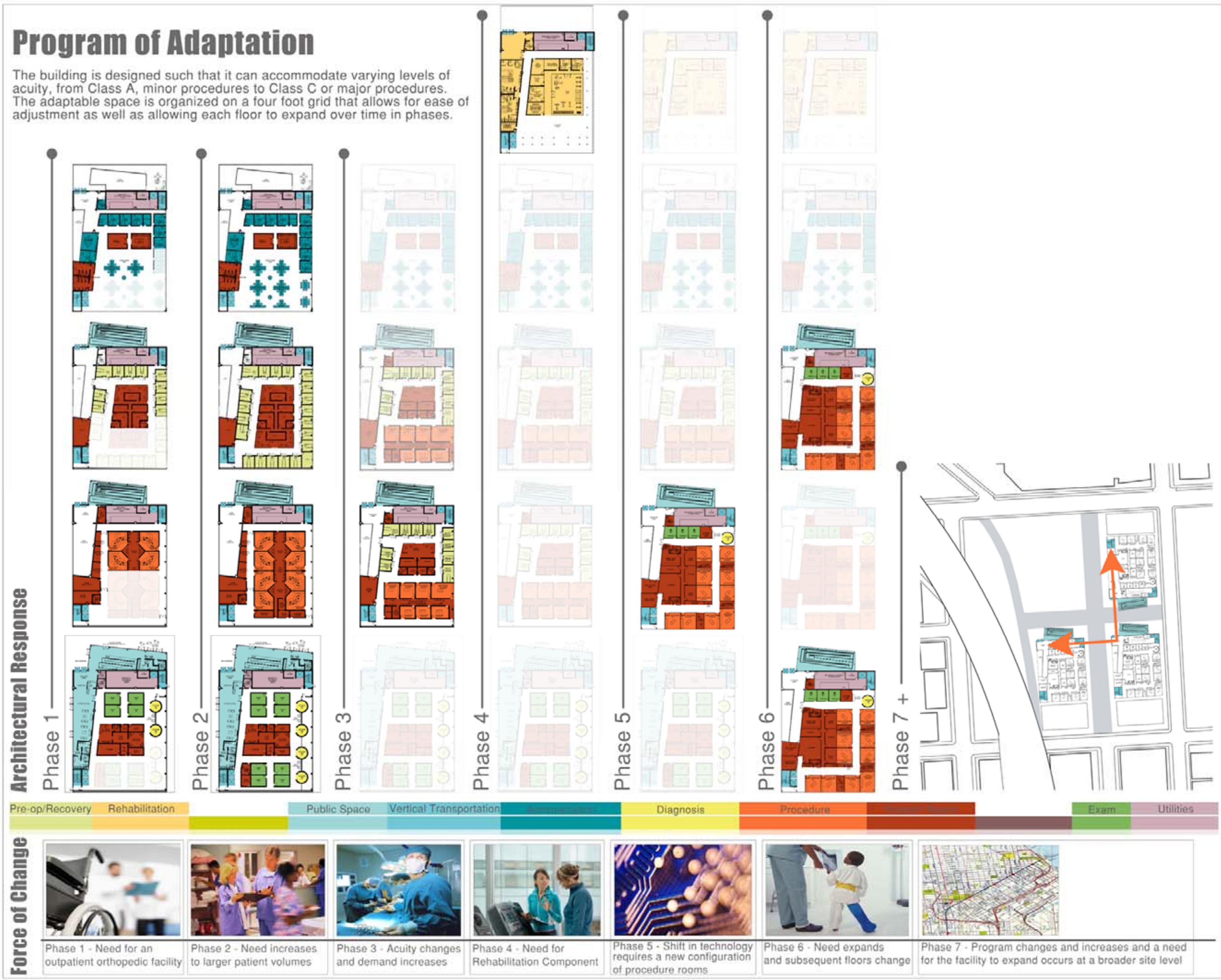


Fig. 99 Program Project Board

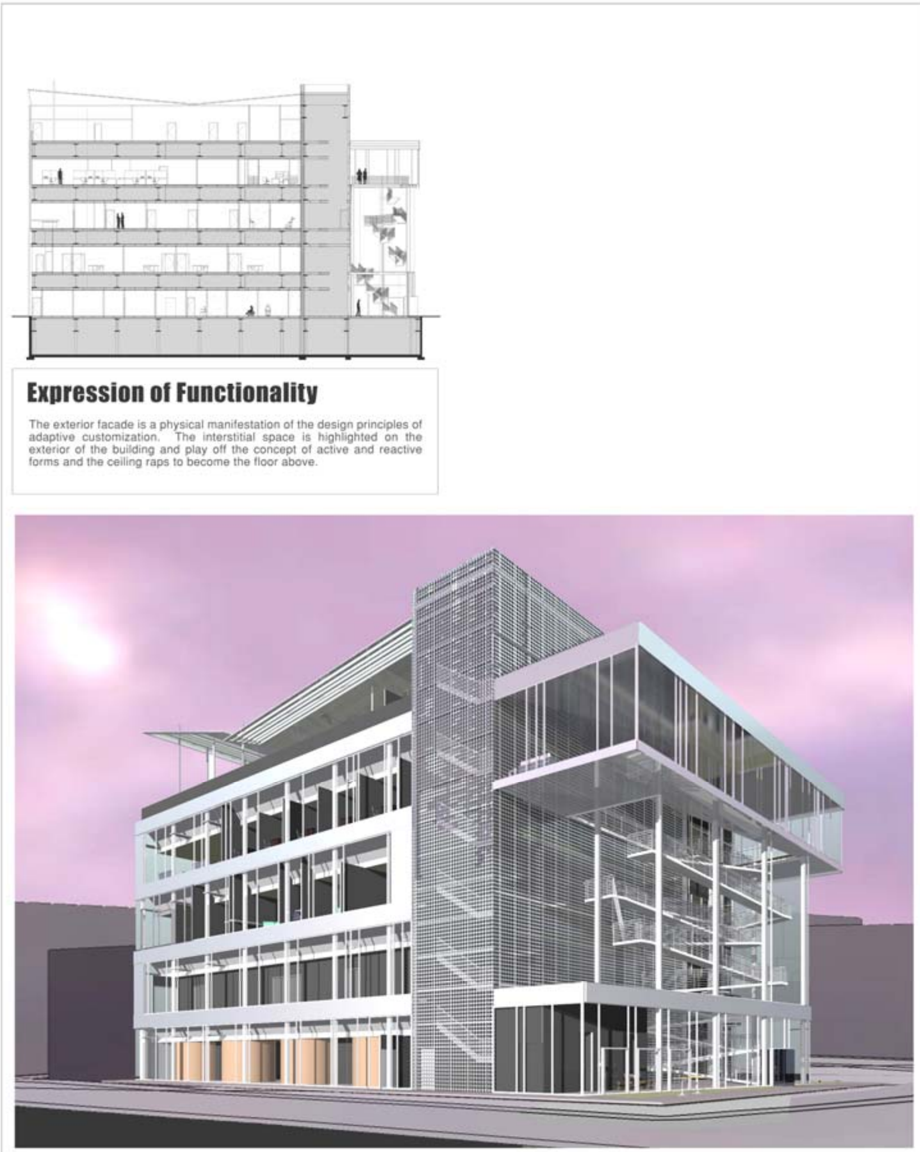


Fig. 100 Project Board 1

Fig. 101 Project Board 2

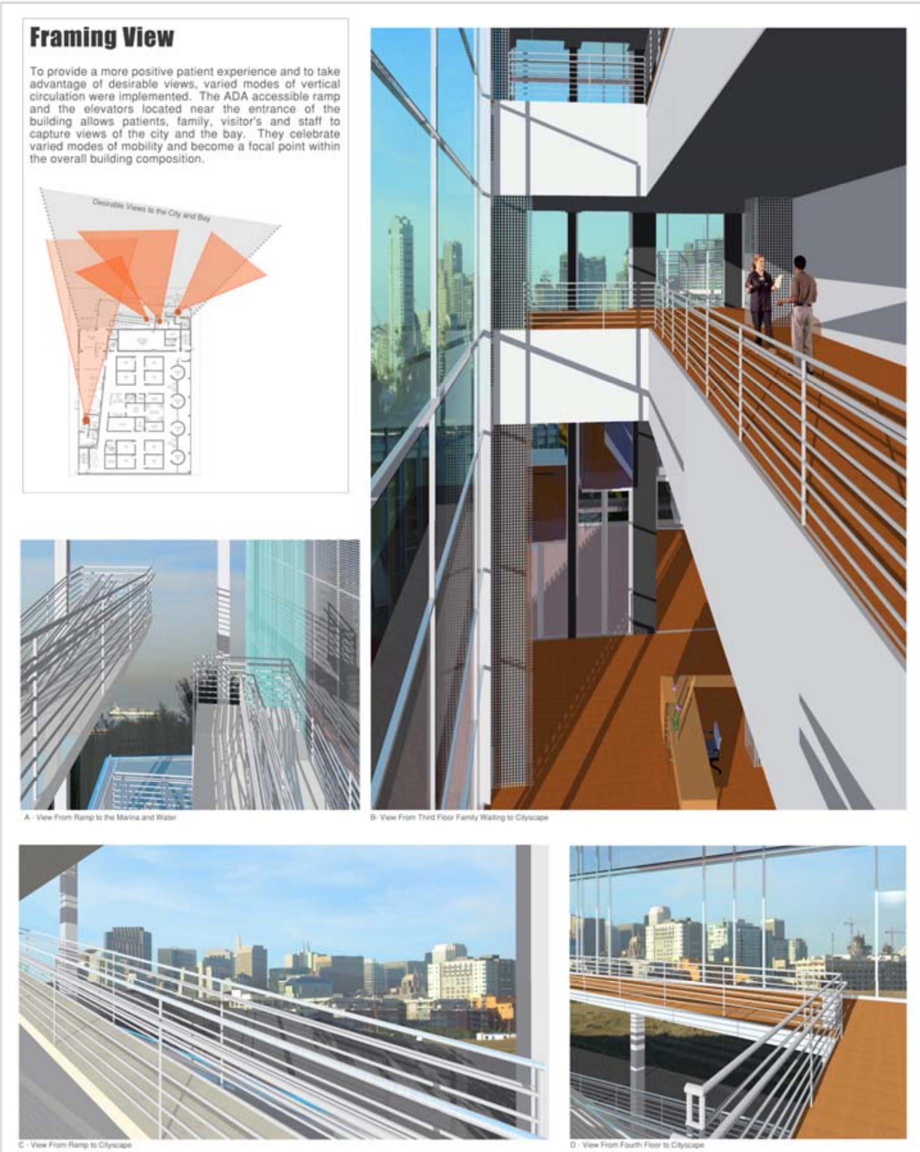


Fig. 102 Project Board 3

Fig. 103 Project Board 4

Fig. 104 Study Model

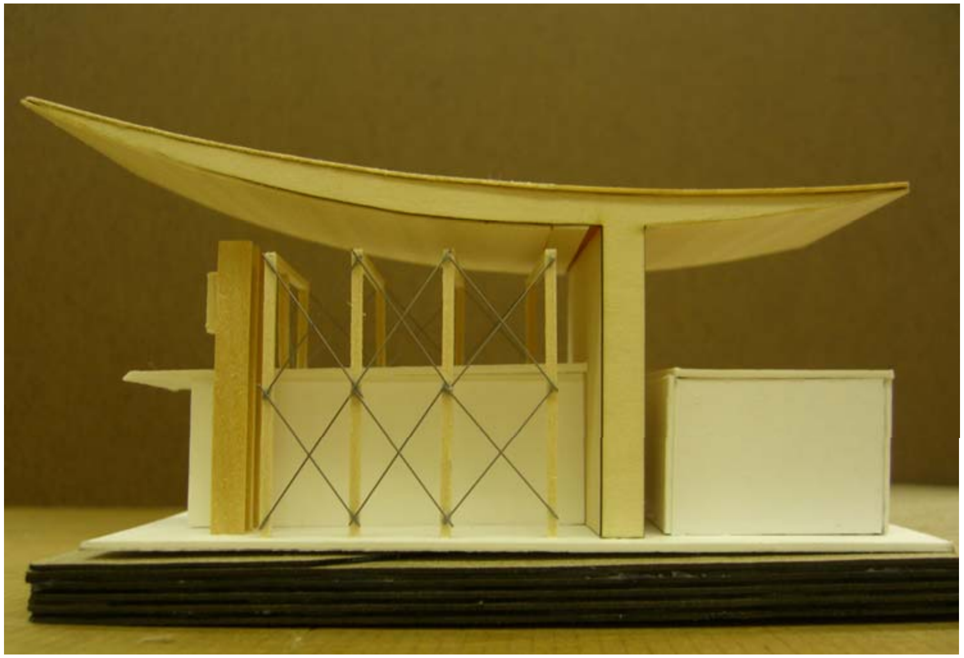


Fig. 105 Study Model

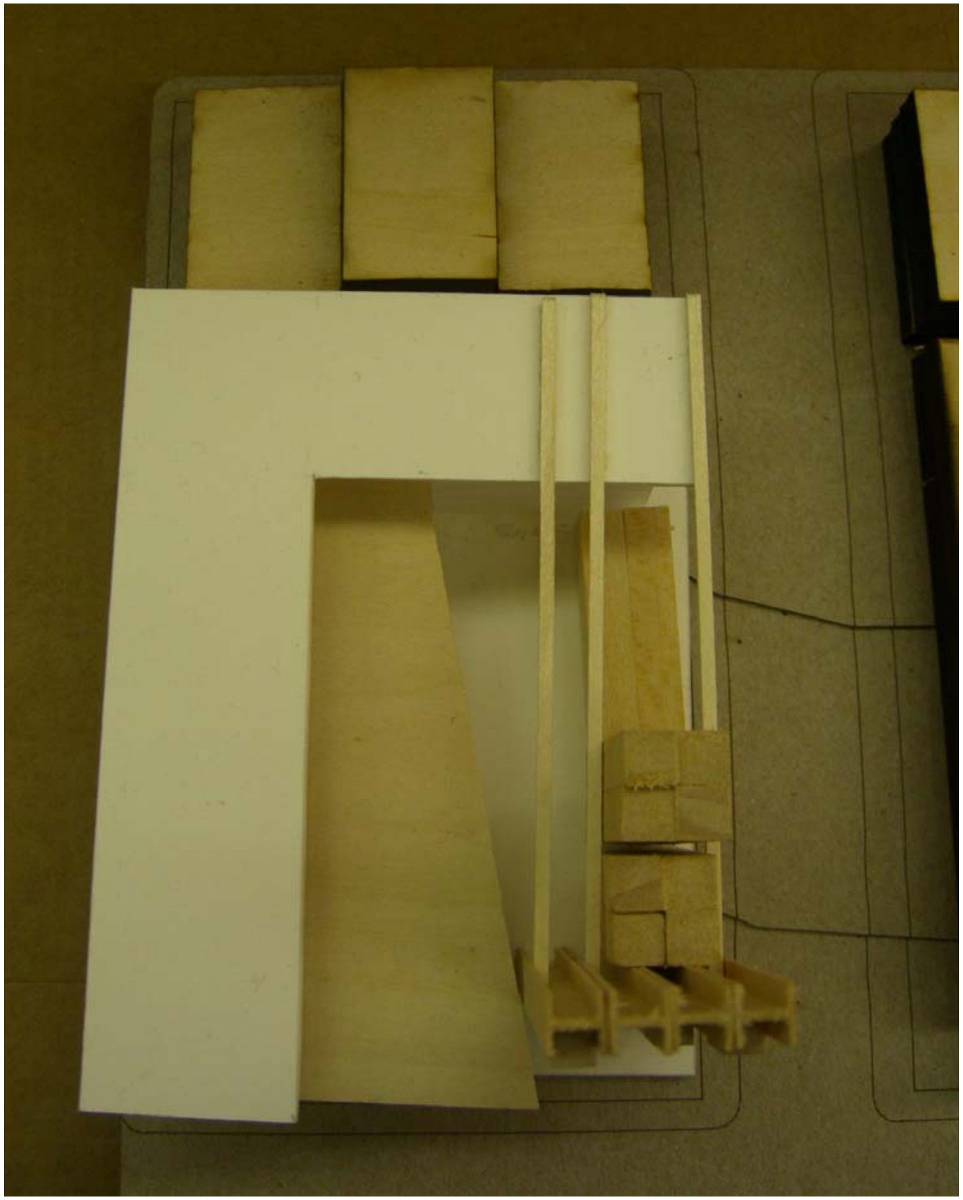


Fig. 106 Study Model

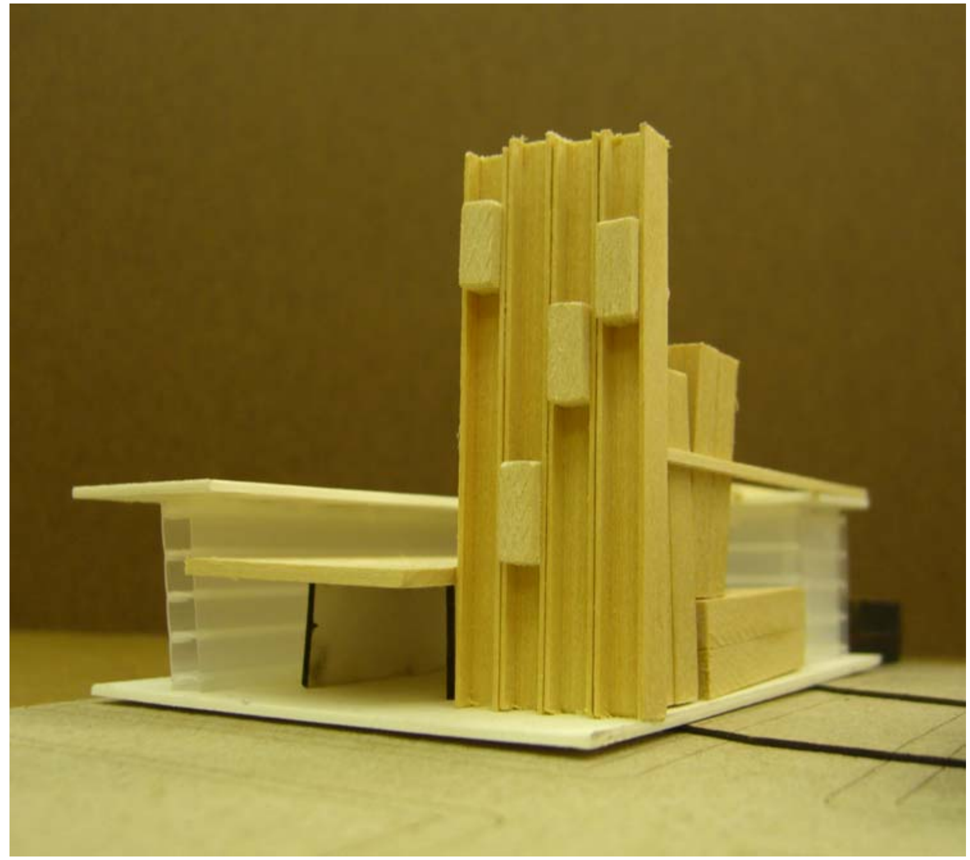


Fig. 107 Study Model

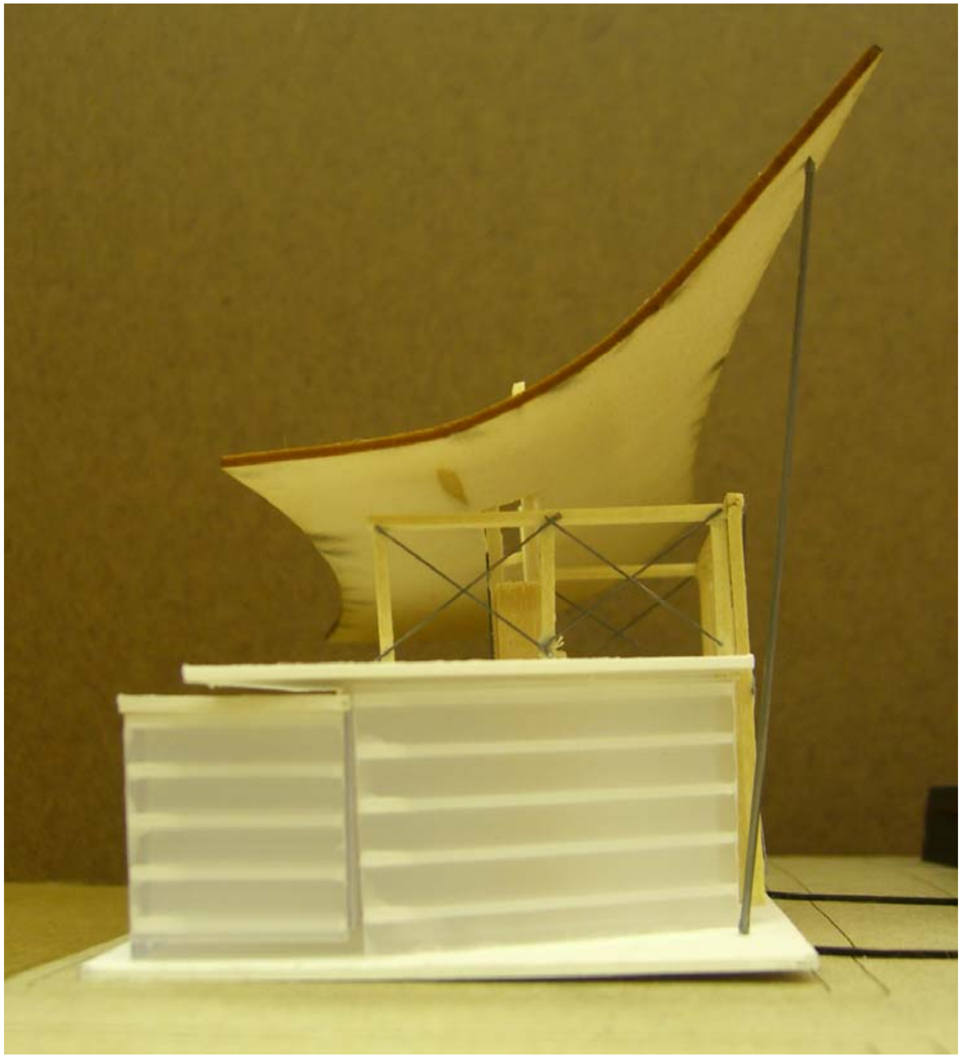


Fig. 108 Study Model

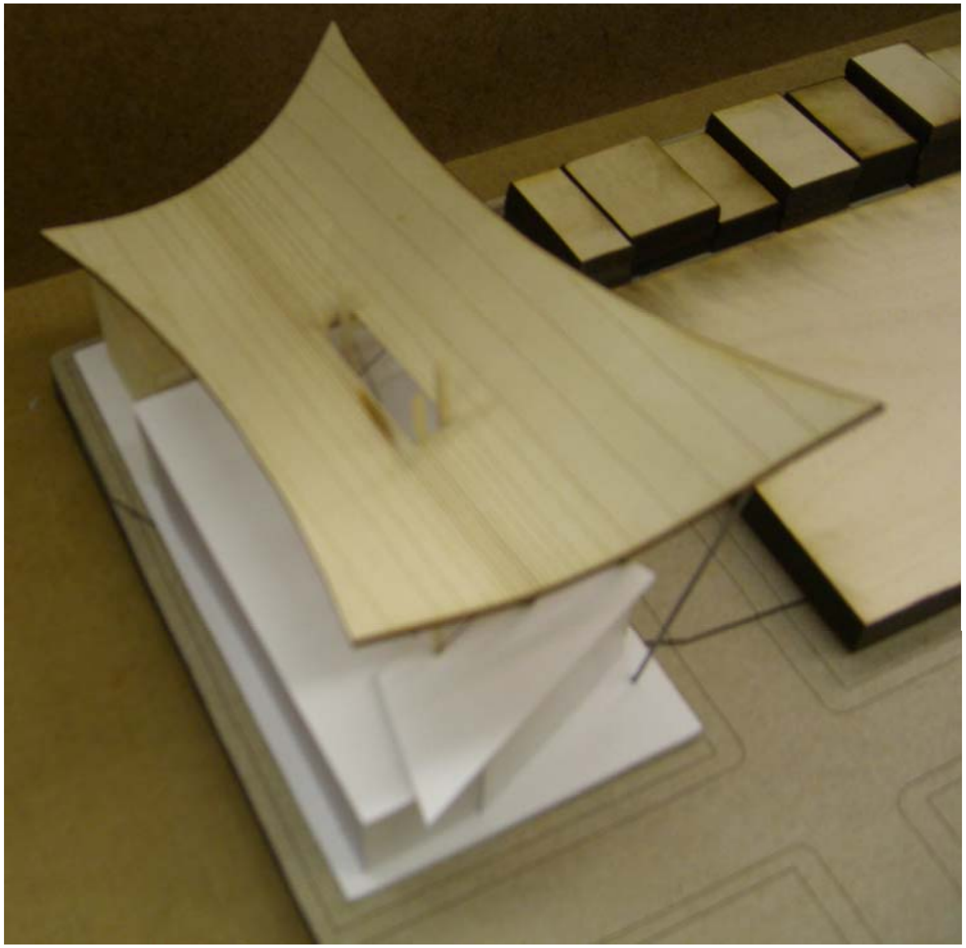


Fig. 109 Study Model

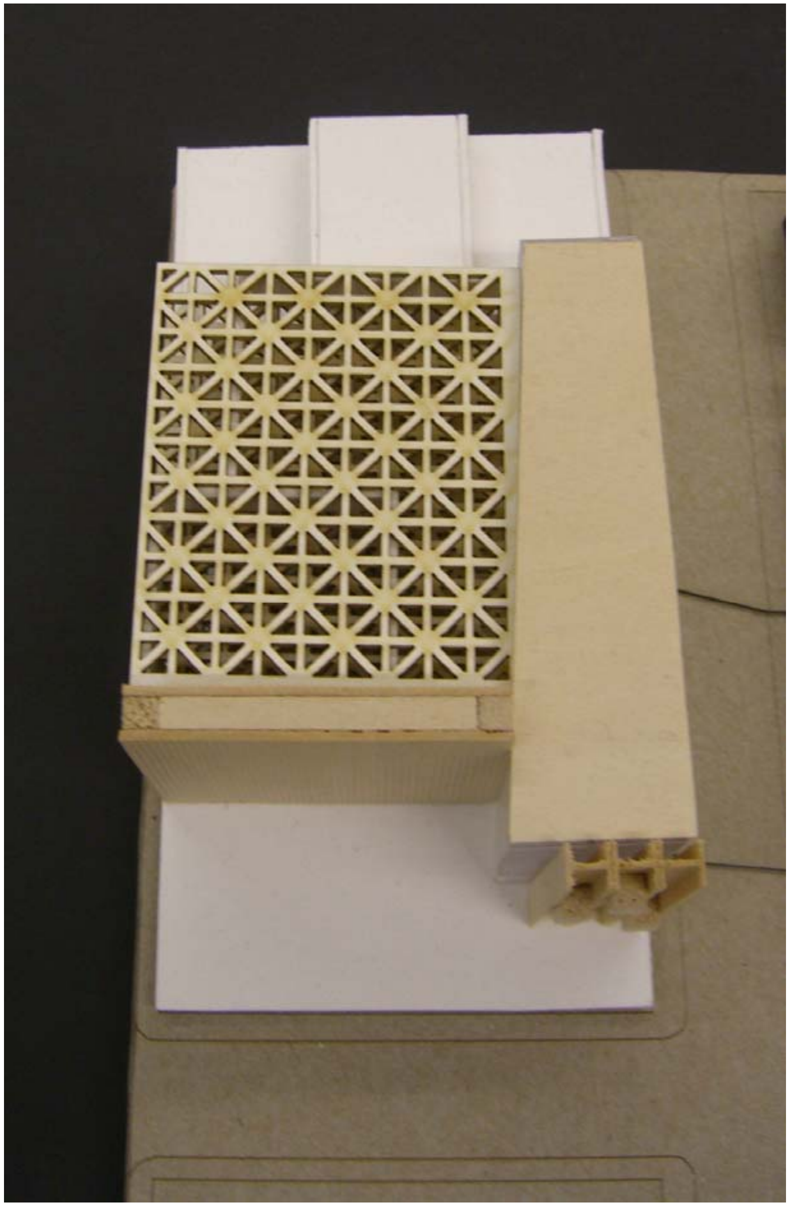


Fig. 110 Study Model

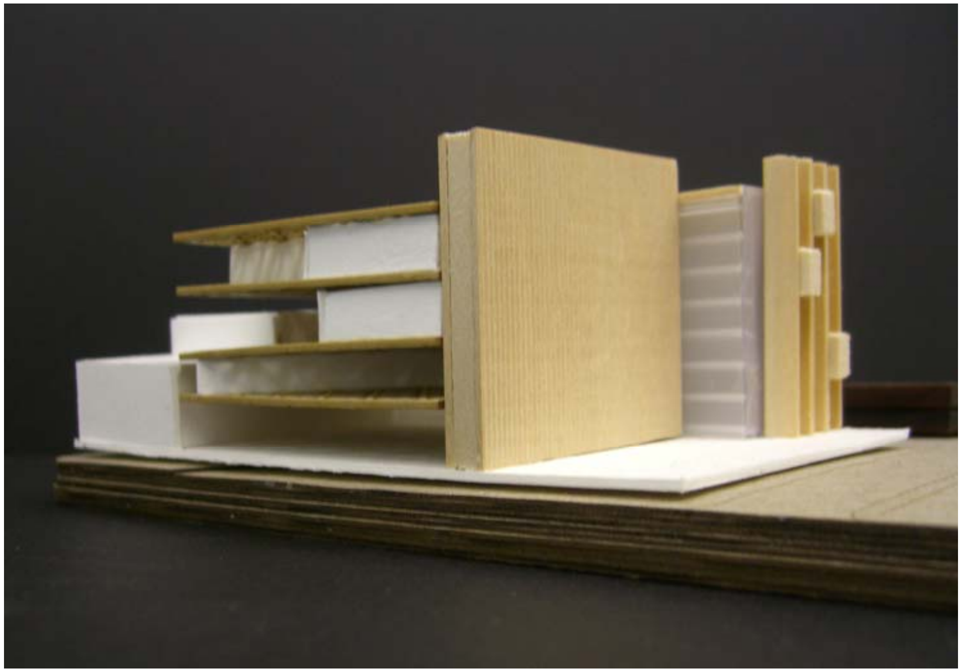


Fig. 111 Study Model

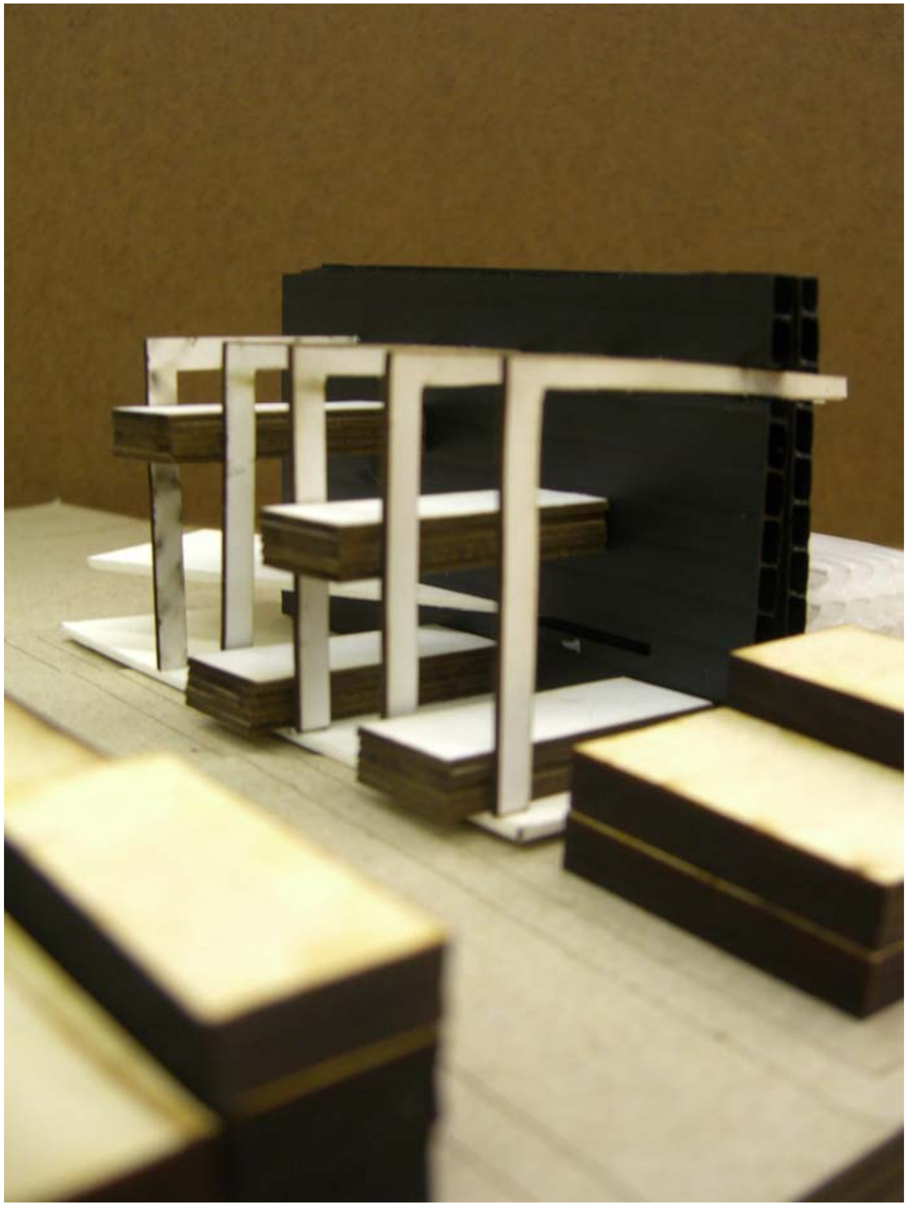


Fig. 112 Study Model

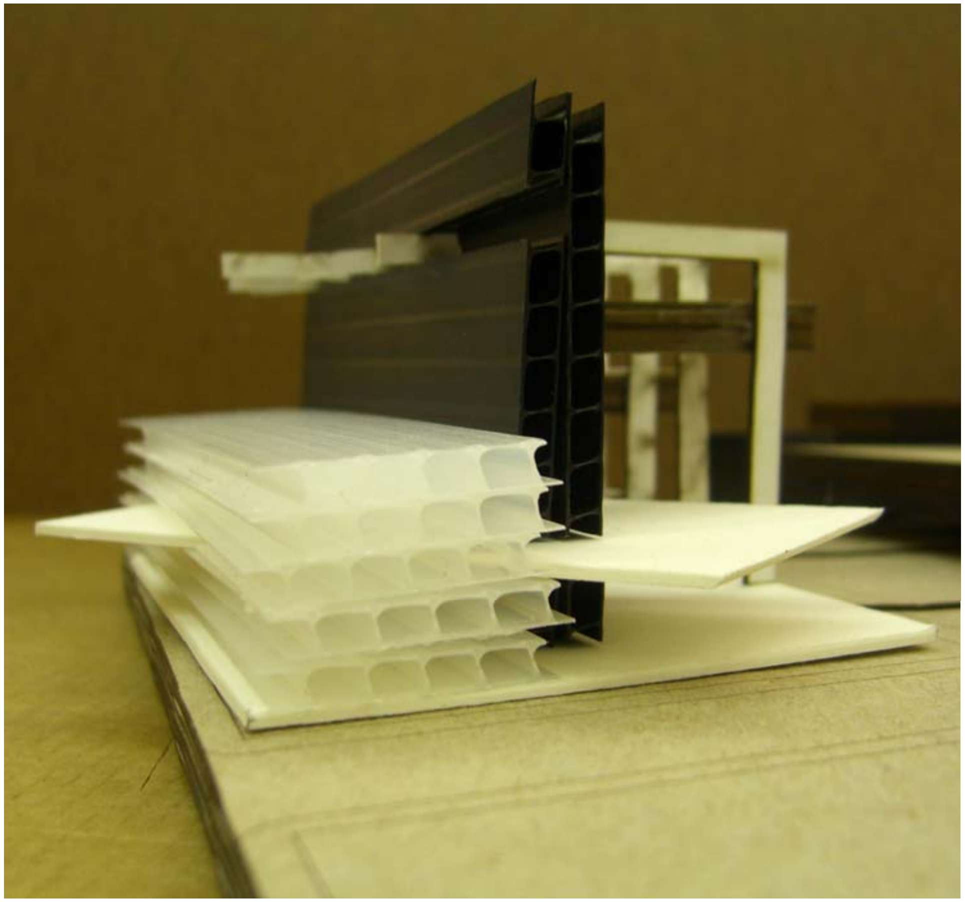


Fig. 113 Study Model

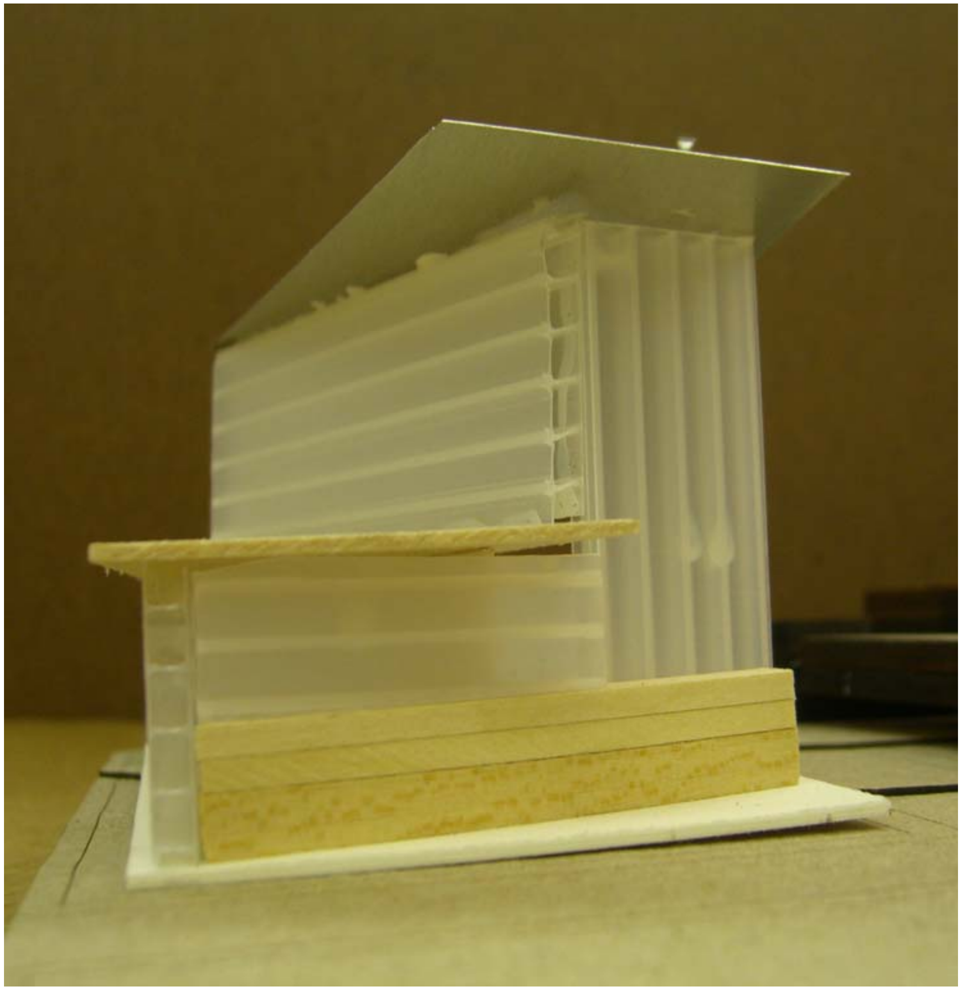


Fig. 114 Study Model


Fig. 115 Study Model

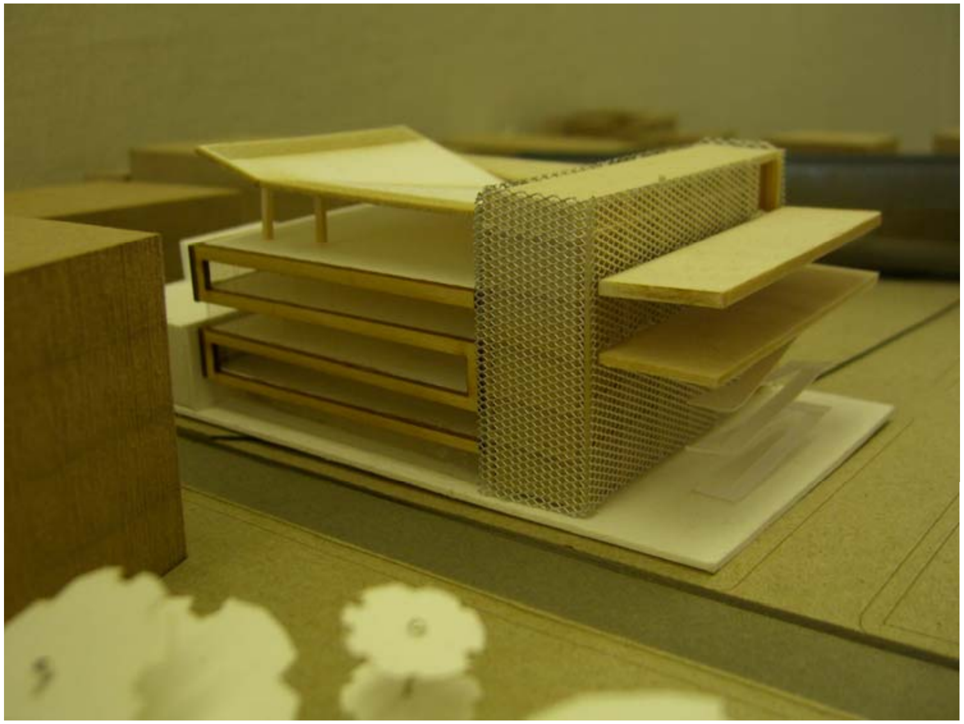


Fig. 116 Final Design Model – East View

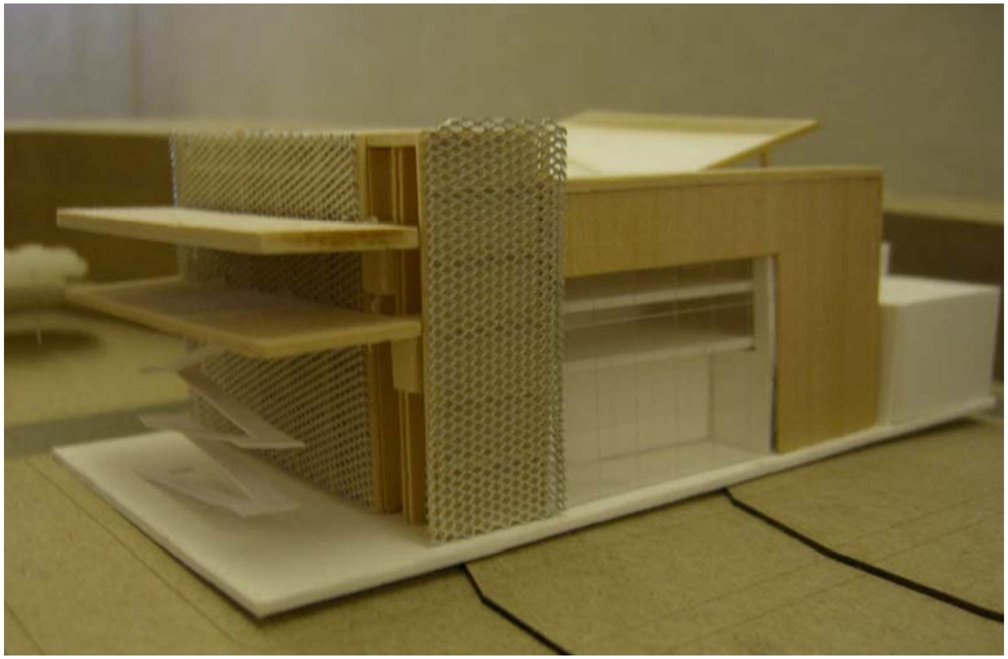


Fig. 117 Final Design Model – West View

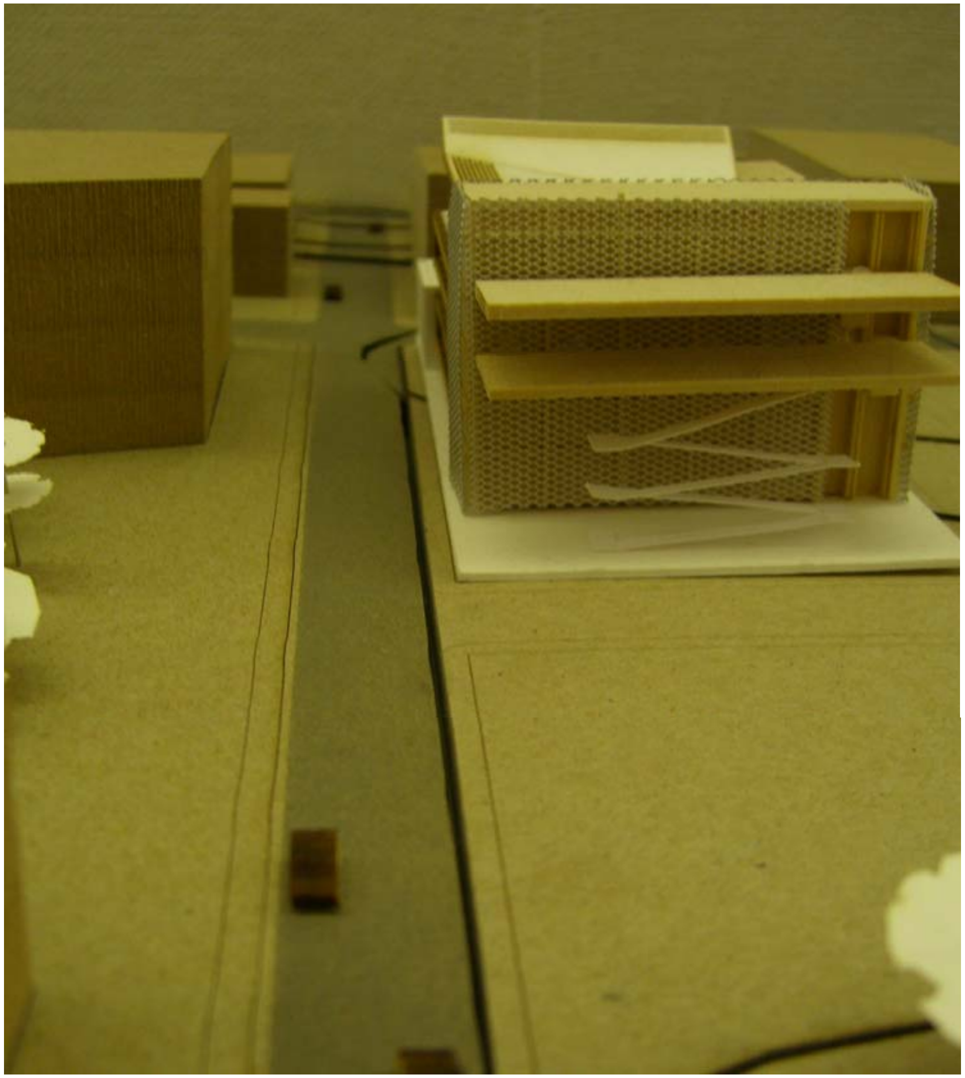


Fig. 118 Final Design Model – North View

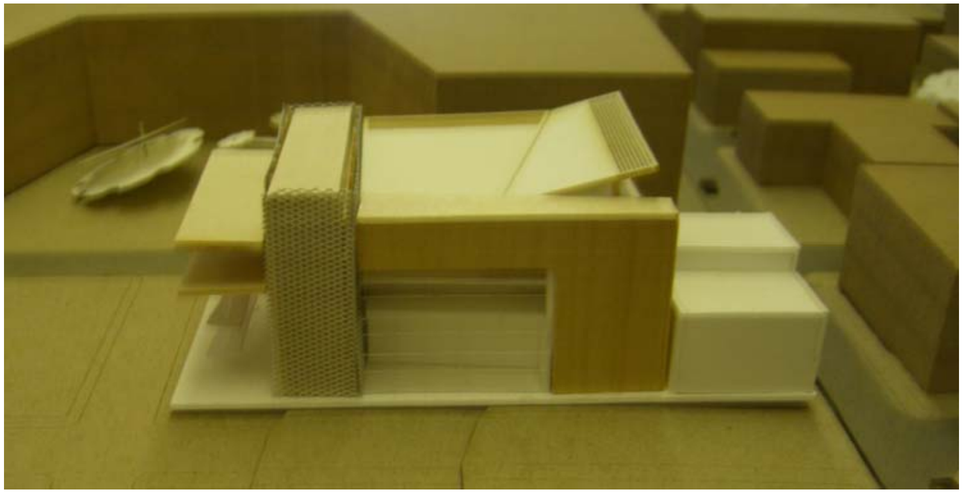


Fig. 119 Final Design Model – West Elevation

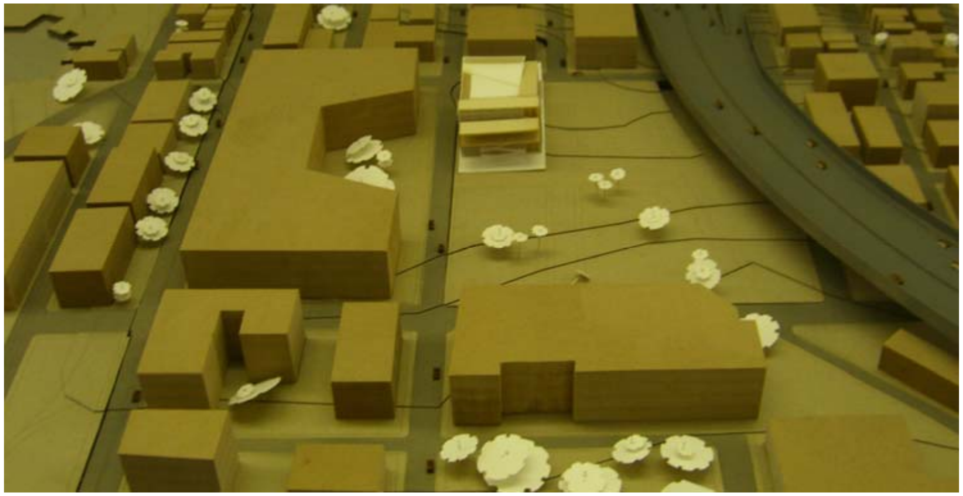


Fig. 120 Overall Final Design Model

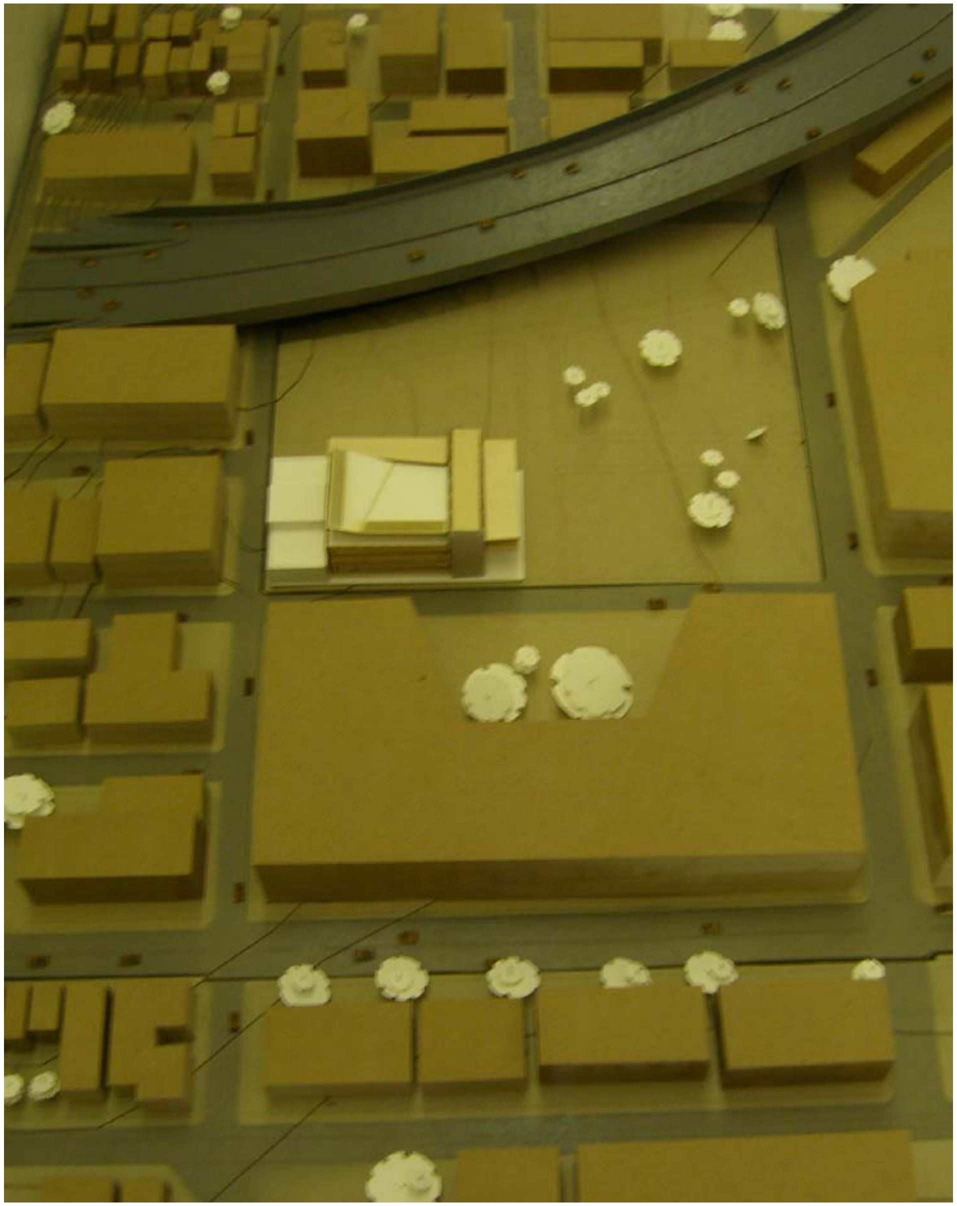


Fig. 121 Overall Final Design Model 2

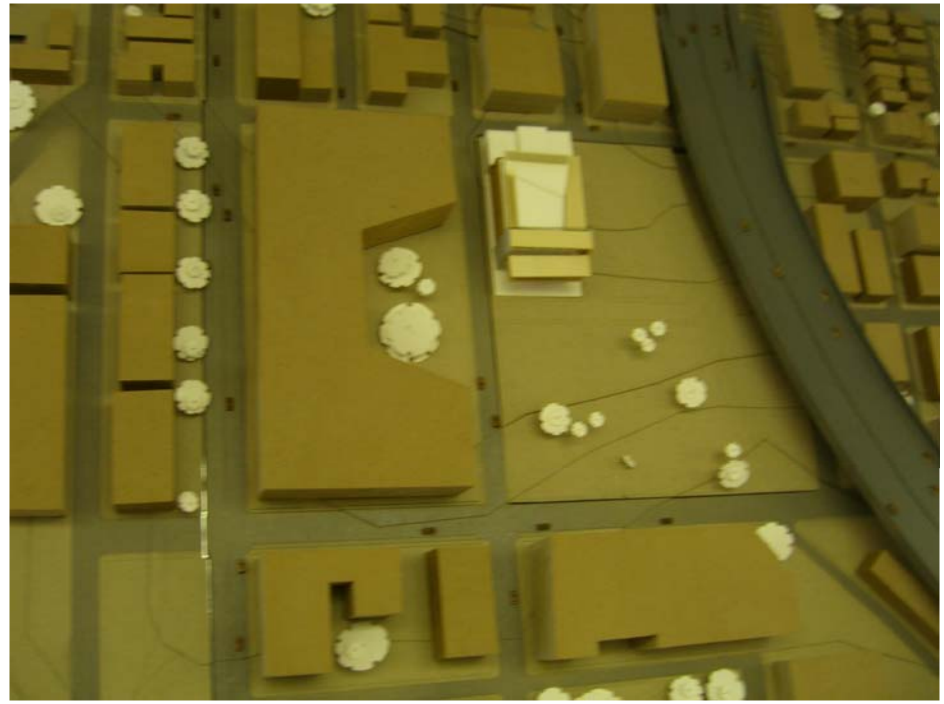


Fig. 122 Overall Final Design Model 3

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