UNIVERSITY OF DETROIT MERCY
GRADUATE SCHOOL
MASTER'S PROJECT

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
THE DEGREE OF MASTER OF ARCHITECTURE

TITLE: Adaptive [re]Use

PRESENTED BY: Jonathan W. Marshall

ACCEPTED BY:

Will Wittig
Associate Professor, Masters Studio Instructor

Stephen J. LaGrassa
Assoc. Dean, Director Masters Program
School of Architecture

APPROVAL:

Stephen Vogel
Dean, School of Architecture
Adaptive ReUse

Jonathan W. Marshall

Masters of Architecture
The University of Detroit Mercy
School of Architecture
AR 510 & AR 520

Will Wittig, Associate Professor
30th April 2007
# Table of Contents

## Thesis
- Abstract 3
- Project Summary 4
- Thesis Paper 6

## Site
- Criteria 23
- Documentation 24

## Precedent Studies
- Design 33
- Technique 40
- Programmatic 44

## Project Framework
- Interactions 49
- Quantitative Summary 57
- Space Detail Summaries 60

## Design Documentation
- Design Process 75
- Final Thesis Proposal 102

## References
- Annotated Bibliography 102
Over the ages architecture has adapted the human condition to enumerable climates and environments. As technology has advanced architecture has found simplicity of design through the use of mechanically controlled adapted environments. As energy prices begin to climb, these systems of adaptation are becoming increasingly less efficient. As these practices become obsolete architecture must find new ways to adapt to our environments for survival. In this sense architecture is a pre-designed adaptation which we will continually use as the world changes around us. As previous designs begin to fall short we must look for new inspiration, which would logically refer us to adaptations that have succeeded in nature for centuries. How can the ideas of natural adaptation be used to architectures advantage? How can reference to the past begin to better inform us of the change of the future?
"IT IS NOT THE STRONGEST OF THE SPECIES THAT SURVIVES, NOR THE MOST INTELLIGENT; IT IS THE ONE THAT IS MOST ADAPTABLE TO CHANGE."

-- CHARLES ROBERT DARWIN

OVER THE PAST FEW CENTURIES ARCHITECTURE HAS BEEN DEVELOPING ON A TRAJECTORY THAT HAS LED MANY OF ITS PROJECTS TO THEIR OWN DEMISE. A BUILDING'S RESPONSE TO ITS ENVIRONMENT HAS BECOME LESS AND LESS IMPORTANT IN DESIGN AND CONSTRUCTION. THIS HAS LED TO A HIGHER LEVEL OF QUESTIONING OVER WHETHER BUILDINGS ARE TRULY FUNCTIONAL OR NOT. TODAY BUILDINGS CAN BE FOUND IN MANY DIFFERENT DEGREES OF EXPIRATION. SOME BUILDINGS EXIST IN A STATE OF COMPLETE EMPLOYMENT, WHILE OTHERS HAVE BEGUN TO COLLAPSE, AND STILL MORE ARE MAINTAINED PRIMARILY FOR HISTORICAL PURPOSES. WHAT IF BUILDINGS OF TOMORROW EMPLOYED TECHNOLOGY WHERE BUILDINGS REMAINED FUNCTIONAL OVER LONG PERIODS OF TIME, NOT SIMPLY TO PRESERVE THEM OR BECAUSE WE CAN NOT AFFORD TO REPLACE THEM, BUT BECAUSE THE BUILDING IS ABLE TO ADAPT AND CONFORM TO OUR NEEDS?

ADAPTATION IS A VITAL PROCESS IN THE SURVIVAL OF ALL LIVING PLANTS, ANIMALS, AND ECOSYSTEMS. EACH ENVIRONMENT AND SPECIES DEVELOPS ITS OWN APPROACH TO ADAPTING WITH ITS ENVIRONMENTS CONDITIONS. AS HUMANS WE HAVE FOUND THAT THROUGH OUR USE OF TECHNOLOGY, WE DON'T ALWAYS HAVE TO ADHERE TO THE LAWS OF NATURE AND THE VALUES OF ADAPTATION. AS BUILDING TECHNOLOGIES HAVE EVOLVED OVER THE CENTURIES, OUR BUILDINGS HAVE SLOWLY ABANDONED ACKNOWLEDGEMENT OF THEIR SOLAR ORIENTATION AND LOCAL CLIMATE.
Environmental conformity has been traded for mechanical adaptations that focus directly on their immediate internal affects, having little regard to their long term external effects.

To guarantee survival, architecture must adapt not only to the world around it, but also to the functions within. Buildings designed for a single existing function with a limited understanding of the environment begin to become inept as soon as either condition shifts. These buildings ultimately become vacated and abandoned, much like the fossils left behind by animals which failed to adapt.

Instead of using the building technology sciences to avoid adaptations, we should begin to focus on creating more suitable adaptations. Adaptable design should not only be receptive to the conditions exerted upon it but should inspire and persuade new adaptations within its environment. An understanding of our environment allows us and requires us to be leaders in the evolution of the world.

Technology has been the Homo Sapiens' key to adaptive survival. Now that our technical capabilities have reached a point where inanimate entities can be as responsive as living organisms, we have the responsibility to design buildings to be equally responsive, and allow them to anticipate their own adaptations.

Knowledge can be as useful to a building as it is to us. A building with a knowledge of its environment not only creates an interaction between use and user, but creates a more efficient building in all senses of the word. The refocusing of architecture on adaptation and conditional understanding will ultimately reduce both material consumption and disposal, beginning to balance the ecosystem, and increasing our chances to survive in a perpetually changing world.
In past years architecture has taken an approach to the environment's elements that are not dissimilar from the approach of a stone. A building designed as a static object can only do its best to cast off the elements that beat against it, in hopes that it will be able to outlast the conditions. If architecture is recognized as a person's adaptation to the environment, then it is unlike any other adaptation found around the world. Its lack of response to change makes it inferior to the average kinetic adaptation. History proves that "It is not the strongest of the species who survives, nor the most intelligent; it is the one that is most adaptable to change," Charles Darwin. Adaptation has been a vital process that all living organisms have employed to sustain their existence in an ever changing world. In addition, the building must also be considered that architecture faces the challenge of adapting to its internal functions, and thus acts as an intermediary between two environments. This compromise creates an increasingly complex situation that would be best served by a dynamic form of adaptation. By implementing the technologies we have today it is plausible that architecture can be responsive to its environment. A dynamic building could react to, rather than oppose the environment, minimizing the undesirable environments within the building. This responsive architecture would create longevity for the building's function, lowering its environmental impact, and creating more efficient architecture. The world is constantly changing, whether the change is cycling...
OR PERMANENT. THE EARTH'S REVOLUTION FOR EXAMPLE, CREATES ISSUES TO BE DEALT WITH SUCH AS NIGHT AND DAY, AND WHILE REVOLVING, THE TILT OF ITS AXIS PRODUCES SEASONAL CHANGES. WATER EVAPORATES INTO CLOUDS CREATING OVERCAST CONDITIONS AND EVENTUALLY RAIN FALL. CYCLING CHANGES BECOME EASILY PREDICTABLE, BUT WHEN INTERTWINED WITH NEW LESS PREDICTABLE CHANGES, OUTCOMES CAN BEGIN TO WAIVER. CHANGES SUCH AS THE EFFECTS OF WASTE, ECONOMIC SHIFTS, SOCIETY'S PREFERENCES, ENERGY SHORTAGES, AND FUNCTIONAL NEEDS ALL CHANGE HOW ARCHITECTURE MUST MOLD TO MAINTAIN SUSTAINABILITY.

IN AN AGE WHERE CHANGE IS PROGRESSING AT AN ACCELERATING RATE, WE ARE FINDING THAT EVEN ADAPTIVE REUSE FALLS SHORT, ADDRESSING ONLY SYMPTOMS RATHER THAN THE CAUSE. ARCHITECTURE, A DESIGNED ADAPTATION TO THE ENVIRONMENT, LOGICALLY SHOULD SEARCH FOR NEW FORMS AND IDEAS BEGINNING WITH A STUDY OF EXISTING ADAPTATIONS IN SIMILAR ENVIRONMENTS. ADAPTATION, DEFINED AS SOMETHING THAT IS CHANGED OR CHANGES SO AS TO BECOME SUITABLE TO A NEW SITUATION, IS FOUND IN EVERY ENVIRONMENT AROUND THE WORLD.
Although the majority of architecture remains static, the idea of adaptability is not new to the field of architecture. Architects around the world have worked at making buildings more adaptable to change. Adaptability in architecture has been expressed in three distinct forms, each with its own attitude on adaptability. The first is based on an issue that has been argued for centuries, can a building be designed for every function? The second is an ecological approach, used in many “green designs.” These sustainable designs are usually defined through the employment of a singular dynamic element. The third form focuses on the communicative power of occasionally functional kinetic elements creating designs that resemble sculpture as much as architecture.

A building designed for every function, more or less, is arguably designed for no functions. This form of building has become more common in mainstream practice as people build buildings for the specific purpose of leasing them to anyone and everyone, creating functional benefit for no one. The same issue arises if a building is designed for both a primary use with a secondary use or adaptive reuse to follow. Although this idea seems beneficial, all secondary uses can shift and change making the attempt to design for flexibility potentially detrimental to the program. The office building (shown right) can incorporate numerous functions although the functional benefit will often derive from a system of cubicles the tenant installs. This process allows the tenant to adapt the space although the building on
ITS OWN IS NOT ADAPTABLE. THIS IDEA IS A STRONG CONCEPT FOR ADAPTABLE ARCHITECTURE, BUT LACKS THE PERCEPTION AND RESPONSE OF A TRUE ADAPTATION. BOTH DYNAMIC SHIFTS REQUIRE EXTERNAL FORCES ALTHOUGH LEASED BUILDINGS USUALLY DEPEND ON ELEMENTS FROM EXTERNAL SOURCES BEFORE THE SPACE BECOMES TRULY FUNCTIONAL FOR ANY ONE USE. ADDING CUBICLES MAY CREATE A CHANGED ENVIRONMENT, BUT EVEN THEN THE BUILDING IS CHANGED RATHER THAN CHANGING ITSELF. THUS, THESE IDEAS ARE NOT FULL ADAPTATIONS IN THE SENSE THAT THE FUNCTION MUST ALSO COMPROMISE TO FIT THE BUILDING.

Ecological facade designs often use technology to create "intelligent" or responsive building facades. These designs, controlled by sensors and timers, adjust themselves to the proper configuration to maximize the building's efficiency. The Leppakk building in Helsinki, Finland (shown above) simply opens and closes its double facade to insulate or ventilate the building depending on the external temperature. These shifts are best described as adaptations although it would be overzealous to call these buildings adaptable based solely on a facade design. Buildings such as these commonly address three reasons why an adaptation exists: energy consumption, ventilation, and
PRESERVATION. INTELLIGENT FAÇADES REACT TO THE SUN’S EXPOSURE AND TEMPERATURE SHIFTS, USUALLY BY ROTATING A SYSTEM OF LOUVERS AND REGULATING AIR EXCHANGE WHICH ALLOWS THE FAÇADE TO CONTROL THE HEAT GAIN AND LOSS THROUGHOUT THE DAY. THIS TECHNIQUE OF CONTROL IS AN UNDENIABLY STRONG EXAMPLE OF ADAPTIVE ARCHITECTURE, BUT AT THE SAME TIME IS LIMITED TO ONE OR TWO ELEMENTS OF THE WHOLE BUILDING.

THE THIRD EXAMPLE OF PRACTICED ADAPTIVE ARCHITECTURE IS BASED ON ADAPTATION THROUGH THE USE OF SHAPE, COLOR, AND LARGE SCALE KINETIC FEATURES. SANTIAGO CALATRAVA’S WORKS ARE THE MOST PROMINENT AND BOLD EXAMPLES OF THIS FORM OF ADAPTIVE ARCHITECTURE. THE DILEMMA IN CALLING BOLD KINETIC DISPLAYS ADAPTIVE ARCHITECTURE LIES IN THE FACT THAT COMMUNICATIVE FEATURES ARE CONSISTENTLY EXISTENT IN ARCHITECTURE. ARCHITECTURE, LIKE ANY ART, WILL ALWAYS CONVEY IDEAS TO ITS OBSERVERS, SIMPLY ADDING KINETICS TO THESE FEATURES DOES NOT QUALIFY ITS ARCHITECTURE AS ADAPTIVE. THE DETERMINING FACTOR IS WHETHER THE ARCHITECTURE PRESENTS THIS AS A WASTEFUL DISPLAY OR IF THE COMMUNICATION IS A GENUINE OCCURRENCE BASED ON THE FUNCTIONAL NEED OF THE BUILDING.

THE WALL STREET FERRY TERMINAL IN NEW YORK, NEW YORK IS AN EXAMPLE WHERE THE KINETIC LIFTING OF ITS EXTERNAL WALL IS FUNCTIONAL YET SIMPLY REDUNDANT CREATED TO PRODUCE A MORE COMMUNICABLE GESTURE.
Commonly kinetic architecture such as this is done for the entertainment of the masses rather than for pure function. In this scenario, functionality was the basis but then was left giving way to the kinetic performance produced by the building.

For ages, architectural structures have found themselves battling the elements in order to stand up to the test of time. Archaeology has proven that structures that have been built steady, strong, and unchanging, although bearing the signs of age, have survived ages of change. This design technique created buildings with extraordinarily long life spans. In our modern society, architectural designs with extraordinarily long life spans are no longer practical.

In today’s society, buildings are not designed and built to stand for centuries upon centuries but rather only for decades. The turnover rate for modern technology renders building functions obsolete or inefficient before the initial occupants have vacated the building. Buildings today are built with life spans that will begin to expire at the same rate as the technologies that created them.

The solution to this problem is not to continue to design buildings and tear them down as soon as they reach an age of obsolescence. Instead designers must draw on the idea of adaptability to maintain decent life spans for their buildings. Buildings must have the ability to update and shift themselves to fit the needs of their functions. Only once a building has been updated many times and has reached a point where its function ceases to be useful, only then should it be reclaimed and recycled to supplement the
TECHNOLOGY THAT ERADICATED IT. THIS CYCLE THEN BECOMES ITS OWN
ADAPTATION COMING FULL CIRCLE, TAKING THE USELESS AND REARRANGING
IT INTO THE DESIRED. ALTHOUGH TECHNOLOGIES HAVE BECOME
INCREASINGLY MORE COMPLEX, MANY SUBORDINATE COMPONENTS’ ELEMENTS
REMAIN CONSTANT AND NEVER BECOME USELESS.

ADAPTATION IS AN IDEA THAT CAN ONLY TRULY BE
UNDERSTOOD BY STUDYING THE STIMULATION, OR NEED
BEING PROTECTED OR ENHANCED. DETERMINING HOW
A CHANGE AFFECTS THE NEEDS OF AN OBJECT ALLOWS
ONE TO UNDERSTAND HOW AND WHY THE OBJECT
ADAPTS. CHANGE CAN EFFECT SEVERAL DIFFERENT
CATEGORIES OF NEEDS, WHICH APPLY TO EVERY LIVING
ORGANISM; ENERGY CONSUMPTION, HYDRATION,
PRESERVATION, VENTILATION, MOBILIZATION, AND
COMMUNICATION. ALTHOUGH EACH NEED MAY NOT
SEEM APPLICABLE, EVERY LIVING PLANT AND ANIMAL
USES EACH FUNCTION TO SURVIVE AND THRIVE IN
THEIR OWN ENVIRONMENTS. FOR EXAMPLE, THE
_DIMETRODON HAD A LARGE FIN ON ITS BACK ALLOWING
IT TO REGULATE BODY TEMPERATURE BY REROUTING
BLOOD CIRCULATION THROUGH IT. CACTUSES
PRODUCE A WAXY SECRETION WHICH ALLOWS THEM
to retain water in dry climates. _The Umbonia
Crassicornis disguises itself as a thorn to hide
from predators. _The Hippopotamus closes
its nostrils to maintain lung capacity while
submerged in water. Raccoon’s use claws
TO GRIP AND CLIMB VERTICAL SURFACES\textsuperscript{16}. The Eastern Massasauga Rattlesnake uses a rattle made of dried skin to warn intruders of its presence\textsuperscript{17}. Animals adapt to survive in numerous environments in many different ways, the only question that remains is, how can these ideas be applied to architectural design?

Energy consumption is an idea and application that is becoming widespread in architectural practice. Grouping energy intake into one category makes the concept seem very applicable to architecture although when divided up is something that is found in every adaptation. The trick to energy consumption is to maximize the efficiency and usage of the energy that is passively on site rather than actively pulling energy to the site. Historically, buildings were designed, although passively, with heavy consideration of solar orientation, due to the lack of their ability to combat or provide comparable levels of energy in buildings. In recent years, forced air systems have allowed people to build with little regard to the solar and wind effects on the building\textsuperscript{18}. Now that running these systems is becoming more costly, light, electricity, and heat naturally provided to the site are becoming increasingly valuable. Can a building adapt to maximize or minimize the amount of energy allowed into a building at a particular time?

Hydration or hydrology in general is a slightly more complex issue. Even though a building does require water to supply the needs of the occupants, as development increases, hydrology considerations begin to include water run off. Adapting to a site should not only produce less wasted water, but attempt to avoid a disruption in the rainwater cycle. Allowing water to filter down through the ground, rather than running across it, further altering the site\textsuperscript{19}. Can a building pull its water needs from what
is repelled by its exterior while limiting the deprivation of water that is no longer absorbed by the site?

Preservation is an idea that can be described in several different ways, each of which has a long list of solutions. Preservation can be addressed as the protective attributes of a building while at the same time can be interpreted as the preservation of the area around the building. The idea of collapsibility is also applicable to preservation of space through compacting items during storage. Stored objects are commonly broken or packed down so that they begin to consume less space than they require while in a performance state. Is it possible that all the ideas implied by preservation can be achieved by one single adaptation embodied through the design of collapsibility?

Ventilation, an architectural term for an organism’s process of respiration and filtration, is just as important to a building as it is to a living entity. The circulation of air is not only required for the occupancy of a building, but is the primary element the two environments must exchange while attempting to create an internal environment separate from the natural environment outside the building. No matter what conditions a building is subjected to, it must maintain a certain level of exchange. This depends both on the climatic difference and upon the heating and cooling load exerted on the building at the time. How could the form of a building’s ventilation shift as the occupancy load increases while still responding to climatic differences?

Ideas about mobilization are not as common in the world of architecture; they demand a high level of adaptability of the objects to be mobilized. In active forms of mobilization, components tend to unfold and fold into the most convenient
SHAPE FOR THEIR TRANSPORTATION. Passive mobilization requires elements to unfold into a more expansive state to harness available site energy (such as wind) for mobilization. The complex system of expansion and contraction can also be applied to the ability of a building to shift spaces around itself and the site to increase functionality.

The ability to communicate through adaptation is one of nature's most basic yet important tools, used to deter or attract other animals by altering shapes and colors on the body. Communication adaptations bare the closest relation to the modern architectural practice; both convey ideas through visual and audible cues enticing participants to interact or retreat. These elements, which provide information about the space, tend to be the most simplistic and direct rather than ambiguous and open to interpretation. As in nature, communication in adaptive architecture should be a result of functional adaptations. The features of adaptive architecture are developed in the entanglement of purely functional elements of other adaptations working together.
AFTER AN ANALYSIS OF WHY ADAPTATIONS OCCUR, THE COMPLEX ISSUE OF HOW REMAINS. UNDERSTANDING WHY AN ADAPTATION OCCURS REQUIRES A RELATIVELY MINIMAL AMOUNT OF RESEARCH WHEN COMPARED TO THE DISSECTION AND RE-APPLICATION OF EACH ADAPTATION. BREAKING ADAPTATIONS DOWN INTO THEIR DURATION, INITIATION, FORMATIONS, AND MECHANICAL ELEMENTS, ADAPTATIONS CAN BE MUCH MORE EFFICIENTLY COMPARED TO ONE ANOTHER. THE SIMPLEST FORM OF EACH OF THESE ELEMENTS FORMS THE BUILDING BLOCKS FROM WHICH ARCHITECTURAL ADAPTATIONS CAN BE BASED AND CONSTRUCTED.

SAFETY PLAYS A VITAL ROLE IN THE KINETIC ARCHITECTURE OF THE SKY CITY RESTAURANT ATOP THE SEATTLE SPACE NEEDLE. THE FULL RESTAURANT MAINTAINS A SAFE FUNCTIONAL ROTATION SPEED ONLY COMPLETING A SINGLE REVOLUTION EVERY HOUR. THIS RATE ALLOWS THE STRUCTURE TO MAINTAIN OCCUPANCY WHILE PROVIDING IT PATRONS WITH A COMPLETE ELEVATED VIEW OF THE CITY. UNLIKE ANIMAL ADAPTATION, ARCHITECTURE IS COMMONLY OCCUPIED BY MANY PEOPLE WHOSE SAFETY IS OF THE UTMOST IMPORTANCE.

THE INITIATION OR CONTROL OF THE TRANSFORMATION IS A PRIMARY ELEMENT IN THE STUDY OF ADAPTATION. SOME ADAPTATIONS ARE NOT CONTROLLED BY THE ANIMAL BUT INSTEAD ARE CONTROLLED BY THE AUTONOMIC NERVOUS SYSTEM LEAVING THE ANIMAL WITH NO CONTROL OVER THE ADAPTATION. OTHER ADAPTATIONS ARE SUBSERVIENT TO THE WILL POWER OF THE ANIMAL, GIVING IT TOTAL CONTROL OVER WHEN AND WHERE TO APPLY THE ADAPTATION. SIMILARLY, ARCHITECTURAL ADAPTATION WOULD MANAGE BOTH MANUAL AND AUTOMATIC TRANSFORMATIONS. ELEMENTS SUCH AS WIND, TEMPERATURE, AND SOLAR EXPOSURE CAN BE PREDICTED AND MEASURED AND CAN THEREFORE BE CONTROLLED AUTOMATICALLY.

OTHER ELEMENTS SUCH AS SPACE REQUIREMENTS, OPENING AND CLOSING OF THE BUILDING, AND PERCEIVED DANGERS WOULD ALL BE CONTROLLED MANUALLY, AS WE CURRENTLY HAVE NO SUCCESSFUL WAY OF AUTOMATICALLY MEASURING AND ASSESSING THEM. UNFORTUNATELY, TECHNOLOGY CAN NOT BEEN DEVELOPED TO
INTERPRET VARYING VOLUMETRIC COMFORT PERCEPTIONS, AND THEREFORE SUBJECTS THE ADAPTIVE CONTROL TO THE HUMAN ELEMENT. THE PAVILION OF KUWAIT IN THE SEVILLE EXPO OF 1992 IS SUBJECT TO PRIOR HUMAN PERCEPTION AS THE SHADING ELEMENTS ARE MANUALLY CONTROLLED TO ACCOMMODATE THE EVENING SKY AND TO ALSO RESPOND TO FUNCTIONAL AND HUMAN VOLUMETRIC NEEDS.

THE FINAL PRIMARY ELEMENT OF ADAPTATION IS THE NUMBER OF STAGES AT WHICH AN ADAPTATION CAN BE CONSIDERED FULLY TRANSFORMED. JUST AS CHANGE DOES NOT ALWAYS OCCUR IN ONE STEADY STEP, KINETIC ADAPTATIONS MAY COME TO REST AT DIFFERENT LEVELS OF SHIFTING, AS TO NOT OVER COMPENSATE FOR THE PROBLEM AND THEREBY CREATING A NEW ONE. ADAPTIVE ARCHITECTURE SIMILARLY SHOULD NOT NECESSARILY BE AN A/B OR ON/OFF FORM OF TRANSITION. ENVIRONMENTAL EFFECTS ARE NEVER EITHER ACTIVE OR DORMANT AND THEREFORE ANY REACTIONS RESPONDING TO THOSE SHIFTS SHOULD NOT BE AS SIMPLISTIC AS TO DISPROPORTIONATELY RESPOND. ADAPTIVE RESPONSES SHOULD ALSO NOT BE LIMITED TO A LINEAR A-B-C STATE OF TRANSFORMATION. ADAPTATIONS RESPONDING TO MULTIPLE NEEDS IN TRANSFORMATION MAY SHIFT FROM C TO K AND THEN TO A. THE SIMPLEST FORM OF STAGED ADAPTATION EXISTS IN A POCKET KNIFE. THE KNIFE CAN MOVE FROM A BLADE TO CLOSED TO BOTTLE OPENER TO SCREWDRIVER THROUGH A FEW SIMPLE FOLDS AND REORIENTATIONS. THE POCKET KNIFE COMBINES THE FUNCTIONALITY OF A KNIFE TO A CORKSCREW, WHILE FOCUSING ON THE IDEA OF SPACE CONSERVATION AND SAFETY WHILE IN ITS CLOSED STAGE. THE POCKET
Knife can shift from formation to formation creating multiple stages of adaptation and use.

Implementing concepts already provided by nature allows architecture to remain timely throughout its lifespan. The architectural strategies that may develop through this adaptive concept would allow a building to exist and be removed with minimal waste or site impact. The concept of adaptable architecture is not to design for the long term future by compromising the present. It is simply the idea that by referencing nature's examples, building designs can shift along with the natural changes of their environment to provide for the needs of the building and site. The aesthetic appeal of this architecture will come from the complexity of overlapping functional adaptation. The display of pure response and compromise between man and nature will render true aesthetics similar to those produced through the functions of the natural world. A new aesthetics based on the understanding of survival, dependency, and compromise; would lead to a new architecture that supports life rather than conquering it.

(Left) Lightning taking the path of least resistance as it travels through the sky is one example of functional beauty produced by nature.

Adaptive Use
ENDNOTES

1 Quote by Charles Darwin stated during his research of evolitional progression.


SITE CRITERIA

ADAPTIVE BUILDING DESIGN IS A TECHNIQUE THAT IS INHERENTLY APPROPRIATE FOR ANY NUMBER OF SITES AND ENVIRONMENTS. EACH SITE CREATES A NEW VARIETY OF CHALLENGES AND OPPORTUNITIES THAT MAY BE INCORPORATED INTO THE BUILDINGS ADAPTATIONS. EVERY COMBINATION OF ENVIRONMENTAL EFFECTS CREATES A NEW BUILDING DESIGN. SEVERAL CRITERIA CHOSEN TO ENHANCE THE BUILDING PROGRAM INCLUDE SOCIAL, CLIMATIC, AND GEOGRAPHIC CONDITIONS.

- HIGHER LEVELS OF PEDESTRIAN TRAFFIC IMPLIED BY THE PROGRAMS PUBLIC ATTRIBUTES SUGGESTS AN EXTERNAL ENVIRONMENT WITH A SIMILAR LEVEL OF FOOT TRAFFIC AROUND THE BUILDING.

- A TEMPERATE CLIMATE DEMANDS THE HIGHEST LEVEL OF CLIMATIC FLEXIBILITY THROUGHOUT A SEASONAL YEAR. THE DESIGN MUST HAVE THAT ABILITY TO INSULATE AND HEAT ITSELF IN THE WINTER WHILE STILL RETAINING THE ABILITY TO OPEN ITSELF FOR COOLING DURING THE SUMMER.

- THE BUILDING SHOULD BE POSITIONED TO STAND AS A REFERENCE EXAMPLE FOR OTHER OFFICE BUILDINGS IN THE AREA.
Phase 1: Analysis of Possible Project Sites
DETROIT, MICHIGAN

2.3 ACRES LOCATED ON THE NORTHEAST CORNER OF GRAND RIVER AVE. AND WEST ELIZABETH STREET

THE DETROIT SITE IS IN AN EXTREME URBAN ENVIRONMENT THAT IS CURRENTLY IN THE PROCESS OF URBAN RENEWAL. THIS BROWN FIELD SITE IS LOCATED SEVERAL BLOCKS FROM THE CITY CENTER, GIVING THE SITE THE POSSIBILITY OF STRONG PEDESTRIAN TRAFFIC, ALTHOUGH FOOT TRAFFIC AROUND THE SITE IS CURRENTLY LOW. HIGH-RISE BUILDINGS IN THE SURROUNDING AREAS GIVE THE SITE A STATIC BACKDROP, WHICH CAUSES THE SITE TO RETAIN A VERY STERILE FEELING. ALTHOUGH AFFECTED BY ITS URBAN ENVIRONMENT, DETROIT FEATURES FULL SEASONS CREATING CONDITIONS FOR BOTH HEATING AND COOLING THROUGHOUT THE YEAR. AS GASOLINE PRICES INCREASE, DETROIT'S STRONG HOLD IN THE AUTOMOBILE INDUSTRY CREATES STRONG SUPPORT FOR ENVIRONMENTALLY FRIENDLY BASED RESEARCH DEVELOPMENTS.
Golden, Colorado

2 acres located just north of Golden's Historic downtown district.

Golden's small town social environment offers a strong sense of community with a high level of pedestrian traffic throughout the city. Although the climate retains a somewhat arid climate, the region still experiences a moderate level of seasonal changes, with mountain conditions that can cause severe weather conditions. The region is home to the National Renewable Energy Lab (NREL) which indicates public interest in an ecological based research and development facilities projects for the area.
ANN ARBOR, MICHIGAN

8 acres located on the northwest corner of Plymouth Road and Green Road.

Ann Arbor is a rapidly developing college town with a district devoted to research and development facilities. Located in southern Michigan, the site enjoys a full range of seasons, requiring insulation throughout the winter season and ventilation in the summer.

The site located just north of the University of Michigan Northeast Campus maintains moderate levels of pedestrian traffic around the district despite its suburban setting. Most pedestrian traffic is generate by the University of Michigan’s strong bus transit throughout the city.

The site's low grade gives way to a wetland cutting through the center of the site. The site's low grade also allows buildings surrounding the site to act as a static backdrop to the site creating a visual comparison reference between structures.
Phase 2: In-Depth Analysis of The Selected Site
LOCATED IN THE RESEARCH AND DEVELOPMENT DISTRICT IN THE NORTHEAST AREA OF ANN ARBOR, MICHIGAN. IN THE LAST 30 YEARS THE NORTHEAST AREA HAS BOASTED DRAMATIC LEVELS OF DEVELOPMENT CAUSING INCREASING DAMAGE TO THE SURROUNDING ENVIRONMENT AND ECOSYSTEMS.
Ann Arbor, Michigan

The low lying orientation of the site acts as a natural catch basin and wetland for surrounding storm water runoff. This runoff then flows under Plymouth Road, into the Miller Creek Tributary.

View east across the site towards Green Road.

Night view west across the site from Green Road.

Northern oriented view from Plymouth Road.

View of the surrounding southeast corner of the site.
ANN ARBOR, MICHIGAN

The wind chart (right) displays the average yearly wind estimates broken down into monthly wind roses.

The sun matrix (below) displays the site's shadow patterns and intensity levels in clear condition.

The rainfall chart (left) quantifies the storm water runoff added to the site's wetland due to surrounding impervious surfaces.

The yearly temperature chart (left) displays average monthly temperatures and their corresponding heating degree days.
Further site research began to reveal multiple forms of adaptations found throughout the site which could be drawn upon for inspiration.
Precedent Analysis
The Quadracci Pavilion was Santiago Calatrava's first building to be built in America. Despite its modern design and its kinetic attribute, the pavilion's initial publicity was humbled by the news of the September 11th attack that occurred only a month prior to completion. Calatrava's pavilion which redefines the point between architecture, sculpture, and engineering has sparked a new sense of identity and pride in the residents of Milwaukee. The seemingly weightless Burke Brise Soleil (the wing like shading device) mounted atop the pavilion opens and closes coinciding with the museum's hours of operation. Calatrava's kinetic features, although existent in several of his projects, are only partially the reason why so many are attracted to his radical designs. Although the building's presence is extreme upon approach, once inside the abstract building yields, making sure not to overwhelm the work inside. Instead the Quadracci Pavilion is a work of art that prepares its visitors for the museum rather than drawing attention away for the art.
The Quadracci Pavilion is the second of two additions added to expand the Milwaukee Art Museum. The original art museum (highlighted above), designed by Eero Saarinen shares little with its latest addition which may explain why, apart from its alignment with E. Wisconsin Ave., Calatrava choose to place his most prominent feature at the far end of his long narrow addition.

The museum's first addition in 1975 was designed by David Kahler, a local architect who chose to respect Saarinen's design. Kahler nestled his 120,000 square foot addition into the lake side slope behind the existing art museum. Working with Kahler, Calatrava chose a design that would create a new entrance to the museum, and pull the museum from its institutional look. The new modern addition addresses the public with a white suspension bridge that soars (in comparison to the previous structure) across the expressway dividing the museum from the city.
CALATRAVA'S MODEL BEGINS TO SIGNIFY THE IMPRESSION OF WEIGHTLESSNESS OF QUADRACCI PAVILION.

Plan and elevation express how the pavilion acts as a transition point from an open environment into Saarinen's grid block layout to the north.

Calatrava's water color depicts the visitors' first perception of his building as they begin their long walk across his bridge and into the pavilion.
The Quadracci Pavilion became a precedent study based on the building's ability to convert physically based on the activities that are occurring inside. The wings become a communication to the public announcing the status of the museum to the city. The ability of the museum to adapt (even on a limited basis) shows how the change can not only influence the building but also the surrounding area. The building also addresses the idea of a building's ability to shift large masses in ways that make it appear almost weightless. The building's cantilevered wings, controlled by an invisible hydraulic system, allow the building to maintain clean lines while still maintaining incredible capabilities.

Sequence Photos of the Brise Soleil as it rotates open in the morning to indicate the opening of the museum.
The Quadracci Pavilion addition and Saarinen's earlier building clash tremendously in style and appearance. Although the addition was meant to be a step towards creating a more approachable building, the museum seems to be two distinct buildings rather than one. The original museum, a grayish pre-cast concrete block with small cantilevers, may cause a person slight hesitation before passing beneath. Calatrava's new bridge entrance and pavilion branch far from their foundations but maintains a weightless presence with its banking white arches and its soaring masts.

The project begins to speak about the appearance of weight, which is an important issue when dealing with moving or changing elements. While the movement of Calatrava's pavilion may be beautiful and inspiring, if Saarinen's concrete block began to move it would create a sense of shock, bewilderment and maybe even fear. The weightless look allows patrons to marvel at its massive kinetic sun shading device rather than wonder if it will fall.

The building which gathers a crowd while in motion, is successful in conveying access to the exhibitions within, however it has been reported to be almost a complete failure as a functional museum shading device, protecting art from direct sun. The fact that the kinetic wing disperse light so poorly makes the Brise Soleil more of a sculptural piece rather than a building adaptation.

A view down the atrium shows the large spans of direct light cast through the pavilion's shading wings.
THE BRE (BUILDING RESEARCH ESTABLISHMENT) building exploits two systems for its passive ventilation system. As warm air rises to the ceiling of each floor it is pulled into cross ventilation ducts located within the building's ceiling system. The stack ventilation system located on the south side of the building pulls the warm air through the ducts and into the one of the five stacks to be expelled out the buildings' chimneys. Each chimney is equipped with a fan system that can be activated when excessive cooling is required or in evening hours to aid thermal mass cooling when the stack ventilation system isn’t adequately assisted by solar heating.

The building façade is pulled back behind the stack ventilation system allowing maximum solar exposure to the stacks and allowing for easier shading of the façade’s glazing system. This system is accommodated by a series of louvers at the top of each floor that automatically rotate to block the sun’s angle throughout the day.
The Debis Headquarters Building utilizes a semi active double building facade to aid in regulating the building’s heating and cooling loads. The building maintains the insulating features of a double facade in the winter, but retains the ventilation capabilities of a single facade in the summer. The external facade consists of hundreds of louvers which can open or close depending on external temperatures and the heating loads of the building. This system minimizes the use of the buildings mechanical heating and cooling throughout the year. During the summer months the building can utilize cross ventilation for cooling the building with both facades remaining open. During the cold winter season office workers can manually open the internal facades windows for solar heated ventilation of the work space. Small penetrations in the external facade maintain a minimal amount of ventilation to the internal facade throughout the winter months. In the evening hours the buildings louvers automatically rotate open to attend to the buildings thermal mass cooling.
The Helicon Building

Completed 1995
Sheppard Robson
London, United Kingdom

The Helicon Building adopted a system of louvers that aid in the building façade’s lighting and solar heat gain. This system offers the building better sound and air pollution control than the conventional operable window. Throughout the day the louvers automatically adjust to maintain a desired lighting environment within the building. The building avoids heat gain from the louvers by enclosing them with a double glass façade that allows excess heat build up to be naturally flushed. As hot air is vented it can be reclaimed and used for pre-heating water. Each floor is divided by baffles that can be rotated closed to aid as a thermal barrier in winter conditions. Although not exploited in the design, the wall section begins to suggest that each floor could be baffled separately if vented to the exterior.

The building’s air circulation is controlled by supply vents in the floor and low profile returns built into the lighting fixture. A cooled ceiling also provides low-energy radiant cooling to the building environment.
Programmatic Precedent Analysis
NextEnergy’s Research facility is a 45,000 square foot building located in the heart of Detroit’s TechTown district located on the southwest corner of Second Boulevard and Burroughs Avenue. Although the research facility maintains a closed unappealing façade to the community, the building designates itself as a high-tech facility with clean masonry wall capped with tilted corrugated steel. Housing six large research labs and two half labs NextEnergy is able to pursue and maintain several different areas of research at once. Each research bay either has a loading bay of its own or direct access to a common loading bay for the facility. The facility also includes a small 80 seat auditorium for lectures and presentations. The front of the building is utilized as a showroom/exhibition space where physical projects can be displayed and demonstrated.

NextEnergy’s Mission Statement:

NextEnergy is a non-profit corporation founded to enable the commercialization of energy technologies that positively contribute to economic competitiveness, energy security and the environment.

NextEnergy can be relied upon for objective, technically balanced thought leadership on pressing energy issues and opportunities facing Michigan and the nation, filling critical knowledge gaps between industry and institutions.

NextEnergy stands ready to assist Michigan’s government and economic development leaders in attracting, nurturing and retaining alternative energy businesses and employment opportunities.
NextEnergy is a non-profit research think tank founded to jump-start the new of energy technologies. Acquiring millions of dollars through federal research grant NextEnergy has been able to build a microgrid power pavilion & alternative fueling infrastructure. The company has also been able to develop strong ties with both private and public industries, as well as the United States Military's research division.

Programmatically NextEnergy is a narrower scoped non-profit research facility then the proposed company in this thesis project. Because the facility is slightly smaller scale than the proposed program most space located within NextEnergy's facility are either expanded or duplicated multiple times in the proposed facility. The new research facility will also enclose a functional greenhouse which will aid the internal environment of the facility. NextEnergy also claims that their research labs are completely flexible, although it should be noted that their facility maintains flexibility only through each lab's sterility. The proposed program suggests that the labs are dynamically flexible able to partially adjust to projects that they enclose.
Highlighted in this floor plan the public sector of the building which bisects the private sector, begins to break the relationship between office and lab.

NextEnergy's site plan provides testimony to the idea that program does not stop with the building. With two exterior units NextEnergy is better suited to fit the environment and move its projects into the real world.
## Quantitative Summary

### Indoor

<table>
<thead>
<tr>
<th>Area</th>
<th>Square Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training Rooms and Offices</td>
<td>8,470 sqf</td>
</tr>
<tr>
<td>Auditorium</td>
<td>4,150 sqf</td>
</tr>
<tr>
<td>Showroom</td>
<td>3,800 sqf</td>
</tr>
<tr>
<td>Laboratories</td>
<td></td>
</tr>
<tr>
<td>Loading Bay</td>
<td>3,250 sqf</td>
</tr>
<tr>
<td>3 Research Bays each</td>
<td>2,240 sqf</td>
</tr>
<tr>
<td>3 Research Bays each</td>
<td>1,980 sqf</td>
</tr>
<tr>
<td>2 Research Bays each</td>
<td>950 sqf</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>17,820 sqf</strong></td>
</tr>
<tr>
<td>Bathroom</td>
<td>450 sqf</td>
</tr>
<tr>
<td>Mechanical Room</td>
<td>375 sqf</td>
</tr>
<tr>
<td>Storage</td>
<td>1,010 sqf</td>
</tr>
<tr>
<td>Undesignated and Circulation</td>
<td>8,925 sqf</td>
</tr>
<tr>
<td><strong>Building Total</strong></td>
<td><strong>45,000 sqf</strong></td>
</tr>
</tbody>
</table>

### Outdoor

<table>
<thead>
<tr>
<th>Area</th>
<th>Square Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternate Fuel Platform</td>
<td>5,250 sqf</td>
</tr>
<tr>
<td>Stationary Microgrid</td>
<td>4,450 sqf</td>
</tr>
<tr>
<td>Parking</td>
<td>52 spaces</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>25,500 sqf</strong></td>
</tr>
<tr>
<td>Green Space and Circulation</td>
<td>28,600 sqf</td>
</tr>
<tr>
<td><strong>108,800 sqf</strong></td>
<td></td>
</tr>
</tbody>
</table>
A NONPROFIT RESEARCH AND DEVELOPMENT CORPORATION PROGRAM BEGINS TO TEST THE ABILITY OF A BUILDING TO ADAPT AND COMPROMISE. THROUGH THE DEVELOPMENT OF EACH TECHNOLOGY THE PROGRAMMATIC REQUIREMENTS OF THE BUILDING BEGIN TO SHIFT, THIS CHANGE BEGINS TO TEST THE ADAPTABILITY OF THE BUILDINGS PROGRAM. THE DEVELOPED TECHNOLOGIES FOCUSED ON THE ADVANCEMENT OF BUILDING AND ENERGY EFFICIENCY WOULD BEGIN TO SHAPE AND ASSIST THE BUILDING’S ADAPTATIONS TO ITS FUNCTION. INCORPORATING RESEARCH AND NETWORKING, OFFICE, TRAINING, DEVELOPMENT, AND PUBLIC EDUCATION SPACES, THE BUILDING WILL REQUIRE CONSTANT ADAPTATION TO CONTINUE TO PRESERVE ITS FUNCTIONAL BALANCE. THE PROGRAM IS DESIGNED TO CONSTANTLY CYCLE NEW TECHNOLOGIES RATHER THAN RETAINING THEM FOR PERSONAL BENEFIT AND STIFLING FUTURE DEVELOPMENT. INITIALLY FOCUSING ITS EFFORTS ON NETWORKING AND GATHERING INFORMATION, THE PROCESS WOULD BE ABLE TO ELIMINATE ANY REDUNDANCY IN THOUGHT AND DESIGN OVER WHAT NEW TECHNOLOGIES ENCOMPASS. THE INFORMATION FOUND WOULD THEN DEVELOP INTO NEW IDEAS AND POSSIBILITIES WHICH WOULD BE PRODUCED AND TESTED IN THE COMPANIES’ LABS. AFTER EACH NEW TECHNOLOGY IS DEVELOPED THE PROGRAM WOULD PROCEED TO REEDUCATE ITS EMPLOYEES TO AID FURTHER DEVELOPMENT IN NEW AREAS. PASSING THIS INFORMATION ON TO THE PUBLIC AND OTHER RESEARCH BASED COMPANIES WOULD SEED NEW IDEAS AND TECHNOLOGIES WHICH CAN BE DRAWN UPON IN FUTURE DEVELOPMENTS.

COMMUNICATION / NETWORKING

The major components of the program are keyed towards the ideas of adaptation because each is an important step in the progression of development and advancement of compromise with the environments in which we exist. A well maintained communication and networking program in the building would begin to ensure that time is regarded as a precious commodity in the process of adaptation to change. Guaranteeing that the program is working with the most current technology would ensure that ideas are not redeveloped wasting the time available for the development of new ideas. The world is constantly changing, rendering completed adaptations slowly obsolete which in turn require new adaptations to assist and replace them. Through strong networking and information sharing, each technological advance is ensured to have the strongest and most advanced base point from which to begin research rather than basing ideas off of antiquated technology.
RESEARCH / EXPLORATION

Gathering information from other enterprises and cataloging them allow researcher to have a range of technologies from which ideas can be drawn. The program will maintain a semi-private library consisting of all current and past advancements pertaining to building and energy technology. By researching and exploring these ideas the program seeks to find the most appropriate application for each idea. This system would measure the potentials and draw backs of each, eliminating the majority of poor adaptations in a conceptual stage. Conceptually eliminating poor adaptations, humans would be able to speed their adaptations which naturally take long tedious periods to perfect. Expediting the adaptation process would begin to compensate for man's long lasting ignorance to the changes in our environments.
The idea of testing begins to replace the idea of natural selection found in evolutionary adaptations. Unlike the natural world, humans are able to create situations of limited adaptation, managing the risk before it becomes wide spread and failure becomes life threatening. This phase allows the correction or eradication of the adaptation prior to exorbitant and detrimental failure. Testing pre-formed adaptations affords humans the ability to compensate for lost time, energy, and resources through the minimization of faulty or inefficiently slow changes. The testing environments might be translucent affording onlooker the ability to perceive change, even though the adaptation may not be understood.
PUBLIC INTERACTION / EDUCATION

Public interaction and education shares and distributes these adaptation ideas to the minds of the masses. Once the majority of risk and failure has been eradicated these new technologies can safely be applied to buildings throughout the studied environment. Although seminars and the library are dominant functions of the private program, the rooms should adapt to become accessible to the interested public visiting the building. Implementation is the final step to adaptation and in the human realm this can only be done through self acceptance. Through education the public can acknowledge and accept new and more efficient technologies.
- The function of the program strives to produce concrete applications from beneficial ideas to aid the development of humanity and its environment.
- New ideas developed by the lab should help the building to grow as technology applications are realized and research development begins to shift.
- As technologies are researched and developed they should be documented and stored within a library that begins to act as the heart of the facility constantly educating and fueling its researchers.
- The building's productions should adapt in a way that causes onlookers to stop and begin to explore the application and possibilities of the idea.
- Upon entering the building, the occupant should be able to engage and experience the benefits of the technologies application.
- Through experimentation, the public would be able to learn the concepts of adaptation and take them home and apply the ideas to their own lives.
- As these technologies are applied to homes in different environmental conditions the residents will provide new complications for the program to consider and solve.
- Responding to the public's reactions to the new technologies, the company will reevaluate and advance the adaptations designed by the company.
- Application of these ideas will begin to communicate some of the complexities found in nature as aesthetic elements.
- As people travel to the building, they should be able to not only observe the benefits of these adaptations but also understand the concepts behind them.
- The entrances to the facility should begin to convey human's relationship to their environment and begin to provide insight to the company's mission.
- Rooms located throughout the building should utilize the existing conditions in its search to replicate desired environments within the building.
- The building's primary function is to fabricate adaptations to meet the needs for physical environments within the building.
- Research-based office space should be able to collect and isolate itself to create a space highly adaptable to change.
- Ultimately, the building will educate its employees and patrons so that they might exercise compromise to gain longevity.
# Quantitative Summary

## Interior Programming

<table>
<thead>
<tr>
<th>Public</th>
<th>SQF</th>
</tr>
</thead>
<tbody>
<tr>
<td>130 Seat Auditorium</td>
<td>3,000</td>
</tr>
<tr>
<td>Exhibition Space</td>
<td>4,500</td>
</tr>
<tr>
<td>Greenhouse</td>
<td>14,000</td>
</tr>
<tr>
<td>Lobby</td>
<td>500</td>
</tr>
<tr>
<td>Lounge</td>
<td>2,000</td>
</tr>
<tr>
<td>Restrooms</td>
<td>800</td>
</tr>
<tr>
<td>Library</td>
<td>3,500</td>
</tr>
<tr>
<td><strong>Net Total</strong></td>
<td>28,300</td>
</tr>
<tr>
<td><strong>Circulation and Mechanical</strong></td>
<td>+5,660</td>
</tr>
<tr>
<td><strong>Public Total</strong></td>
<td>33,960</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Private</th>
<th>SQF</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 Research Bays</td>
<td>2,000 avg. - 12,000</td>
</tr>
<tr>
<td>1 Machine Shop</td>
<td>2,100</td>
</tr>
<tr>
<td>3 Education/Conference Rooms</td>
<td>500 avg. - 1,500</td>
</tr>
<tr>
<td>Open Office Space</td>
<td>4,200</td>
</tr>
<tr>
<td>Kitchen</td>
<td>2,200</td>
</tr>
<tr>
<td>Restrooms</td>
<td>500</td>
</tr>
<tr>
<td>3 Mechanical Rooms</td>
<td>900 avg. - 2,700</td>
</tr>
<tr>
<td>Storage</td>
<td>3,000</td>
</tr>
<tr>
<td><strong>Net Total</strong></td>
<td>28,200</td>
</tr>
<tr>
<td><strong>Circulation and Mechanical</strong></td>
<td>+5,640</td>
</tr>
<tr>
<td><strong>Private Total</strong></td>
<td>33,840</td>
</tr>
</tbody>
</table>

**Building Total** 67,800 SQF
<table>
<thead>
<tr>
<th>Exterior Spaces</th>
<th>Interior Programing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shipping and Receiving</td>
<td>1,500 SQF</td>
</tr>
<tr>
<td>Entrance Corridor</td>
<td>2,500 SQF</td>
</tr>
<tr>
<td>Gardening Space</td>
<td>30,300 SQF</td>
</tr>
<tr>
<td>Irrigation Canals</td>
<td>4,400 SQF</td>
</tr>
<tr>
<td>Parking</td>
<td>31,000 SQF</td>
</tr>
<tr>
<td><strong>Site Programing Total</strong></td>
<td><strong>137,500 SQF</strong></td>
</tr>
</tbody>
</table>
Programmatic Diagram

These diagrams show a preliminary volumetric massing of the building's programs and how they can be located on the site. This study provides a basic starting point for initial shape and massing the building will begin to occupy on the site.

- Meeting Halls
- Library
- Research Labs
- Office Space
- Green House
- Storage/Mech.
- Lounge Space
- Restroom
- Existing Structures
QUANTITIES REQUIRED
130 PERSON OCCUPANCY
1 SPACE
3,000SF NET AREA
3,000SF TOTAL NET AREA

PURPOSE/FUNCTIONS
The room will begin to present and inform the public, acting as the voice of the building serving the public with new knowledge.

ACTIVITIES
An area to house formal lectures and structured presentations to both private and public audiences.

SPACIAL RELATIONSHIPS
The high public occupancy is only matched by the similarly functioning exhibition space. Acting as a presentation element of the building, the auditorium will want to be a prominent element to both the inside and outside of the building. Although the room services both private and public function, the capacity of the room suggests that all presentations will draw upon an external audience suggesting it be located by an entrance.

SPECIAL CONSIDERATIONS
The auditorium requires a low level of lighting to adequately allow for the use of a projection system, it also requires a sloping floor to allow for stadium seating to provide visibility from all seats.

EQUIPMENT / FURNISHINGS
130 AUDITORIUM SEATS / FRONT PROJECTION SCREEN / 20 FOOT DEEP PRESENTATION STAGE / ELECTRONIC CONTROL PODIUM.

BEHAVIORAL CONSIDERATIONS
The auditorium floor requires sloping down towards the stage.

STRUCTURAL SYSTEMS
This area requires open spanning system to avoid obstructions.

MECHANICAL / ELECTRICAL SYSTEMS
The space must be wired to accommodate a projection system that can be controlled from the podium located on the front stage. It must also maintain a sound system to adequately project the speakers voice to the audience.

SITE / ENVIRONMENTAL CONSIDERATIONS
The slope of the site could begin to play into the slope of the auditorium floor.
EXHIBITION SPACE

QUANTITIES REQUIRED
170 PERSON OCCUPANCY
1 SPACE
4,500sf NET AREA
4,500sf TOTAL NET AREA

PURPOSE/FUNCTIONS
The exhibition space acts as the public face of the building presenting the public with the products of the building; beginning to seed new ideas through the visual exchange of information, allowing itself serve the minds of the public.

ACTIVITIES
Providing space for new technologies to be displayed and demonstrated. The public must be able to freely travel from exhibition to exhibition.

SPACIAL RELATIONSHIPS
Locating the exhibition near the front entrance of the building would allow for the possibility for the space to be viewed from both inside and outside the building.

SPECIAL CONSIDERATIONS
The room wants to maintain a visual connection to the environments which they were designed for. Bringing natural lighting into the room allows for the room to use less artificial lighting and creates more dispersed lighting throughout the room. The room will also need to be a high bay area including oversized doors for access to larger exhibits.

EQUIPMENT / FURNISHINGS
8 Mobile information kiosks

BEHAVIORAL CONSIDERATIONS
One portion of the room should be fit to hold demonstrations during exhibitions.

STRUCTURAL SYSTEMS
The room must maintain a clear high bay area with a floor structural system to accommodate the weight of the exhibitions.

MECHANICAL / ELECTRICAL SYSTEMS
The room must have enough air exchange to accommodate high heat gain from the visiting public and maintain pressurized air, strong electrical supplies, gas supply, and water supply to accommodate possible demonstrations.

SITE / ENVIRONMENTAL CONSIDERATIONS
None
### Quantities Required
- 8 person occupancy
- 2 spaces
- 400sf net area
- 800sf total net area

### Purpose/Functions
A private public space serving the functional needs of the visiting public

### Activities
None

### Spacial Relationships
The bathroom should be easily accessible from the public domain of the building while still placed as to not disturb other functions.

### Special Considerations
None

### Equipment / Furnishings
Each bathroom should hold 8 stalls with an exception of a 3 urinal substitution in the men's room / both rooms will also contain four wash basins

### Behavioral Considerations
The space must be designed wide enough to accommodate 5ft stalls and passage past them.

### Structural Systems
None

### Mechanical / Electrical Systems
This space should be directly ventilated to the building exterior.

### Site / Environmental Considerations
None
GREENHOUSE

QUANTITIES REQUIRED
30 PERSON OCCUPANCY
1 SPACE
14,000sf NET AREA
14,000sf TOTAL NET AREA

PURPOSE/FUNCTIONS
Acting as a functional element, the greenhouse will also allow the occupants to reconnect to nature while inside the building.

ACTIVITIES
The greenhouse will allow for circulation both private and public functions, adding a calming element to the building's environment.

SPACIAL RELATIONSHIPS
Each greenhouse should be well spaced from the other greenhouses to create a maximal effect on the overall building. Each greenhouse should rise to the roof level allowing natural sunlight to enter the room.

SPECIAL CONSIDERATIONS
The greenhouses will all have to maintain a minimal amount of sunlight for their plants to thrive.

EQUIPMENT / FURNISHINGS
None

BEHAVIORAL CONSIDERATIONS
None

STRUCTURAL SYSTEMS
The roof structural system should be designed to allow for the maximal amount of sunlight penetration.

MECHANICAL / ELECTRICAL SYSTEMS
Each unit requires a strong irrigation and ventilation system to accommodate the hydration and ventilation needs of the plants within it.

SITE / ENVIRONMENTAL CONSIDERATIONS
The greenhouses should maintain a strong physical relationship to the environment, pulling the environment into the building.
LIBRARY

QUANTITIES REQUIRED
20 PERSON OCCUPANCY
1 SPACE
3,500SF NET AREA
3,500SF TOTAL NET AREA

PURPOSE/FUNCTIONS
Acting as the heart and brain of the building the library should retain a central location that is accessible to both the public and private sectors of the building.

ACTIVITIES
The library will house the storage, browsing, research and, photo duplication of all past technology documentation.

SPACIAL RELATIONSHIPS
The library should be located so that it is accessible to public browsing but more importantly located near the private office space to provide access to the private functions of the building.

SPECIAL CONSIDERATIONS
The temperature and humidity of the room must be maintained to properly store and maintain the documented information.

EQUIPMENT / FURNISHINGS
1 photocopying center / 400 lineal feet of 8ft x 1ft shelving / 4 4ft tall 40in. x 30in. flat files / 3 small research tables with chairs / 2 digital search kiosk stations / other data storage systems

BEHAVIORAL CONSIDERATIONS
None

STRUCTURAL SYSTEMS
None

MECHANICAL / ELECTRICAL SYSTEMS
Temperature and humidity should be strictly regulated.

SITE / ENVIRONMENTAL CONSIDERATIONS
None
QUANTITIES REQUIRED
10 PERSON OCCUPANCY
1 SPACE
500sf NET AREA
500sf TOTAL NET AREA

PURPOSE/FUNCTIONS
The lobby is a public welcoming point through which a person can easily make the transition from the natural environment to the built environment. It should also act as an introduction to the functions of the company.

ACTIVITIES
People will be received into the building where they can be directed to the proper area of the building, also functioning as a short term waiting area for visitor to the building.

SPACIAL RELATIONSHIPS
The lobby must be located at the front entrance to the building and have a strong relationship with the external environment.

SPECIAL CONSIDERATIONS
The lobby should be naturally lit during the day to offer the softest transition possible while entering the building.

EQUIPMENT / FURNISHINGS
1 reception desk and chair / seating for 15 people / 4 8ft display areas

BEHAVIORAL CONSIDERATIONS
None

STRUCTURAL SYSTEMS
None

MECHANICAL / ELECTRICAL SYSTEMS
None

SITE / ENVIRONMENTAL CONSIDERATIONS
Located at the intersection of the summer and winter entrances, the lobby should begin to present the building in a manner consistent with the environmental conditions.
QUANTITIES REQUIRED
- 20 person occupancy
- 1 space
- 2,000sf net area
- 2,000sf total net area

PURPOSE/FUNCTIONS
The lounge is a quite place for the employees to escape the office environment. The space should also be offered the public sector creating a mixed atmosphere in the space.

ACTIVITIES
The lounge will be a tranquil environment where people can rest or take a break in a different environment.

SPACIAL RELATIONSHIPS
The requirements of this room suggests a strong and possibly integral relationship with one of the green houses located in the building.

SPECIAL CONSIDERATIONS
The space requires a warm environment filled with natural lighting and the feeling of open space.

EQUIPMENT / FURNISHINGS
- 3 tables w/ 4 seats ea. / 4 couches / plenty of natural dividing vegetation.

BEHAVIORAL CONSIDERATIONS
The space should maintain a minimal level of unnatural or disturbing sounds.

STRUCTURAL SYSTEMS
None

MECHANICAL / ELECTRICAL SYSTEMS
None

SITE / ENVIRONMENTAL CONSIDERATIONS
The room should be located as far as possible from the roads surrounding the site.
Quantities Required
1-6 person occupancy
6 spaces
2,000sf avg. net area
12,000sf total net area

Purpose/Functions
In the research bays various energy and architectural prototypes are assembled and tested. The bays will require both the delivery of material and the removal of variable scale completed building and energy products.

Activities
In these spaces the technologies developed by the research teams are designed, assembled, and tested.

Spatial Relationships
The bays must maintain access to a delivery bay and storage unit. They must also be provided with access to the facilities exhibition space.

Special Considerations
Each bay must have complete independent control over its internal environment in order to maintain complete control over its testing and experimentation.

Equipment / Furnishings
Full range of testing equipment / 1 4ft x 2ft x 5ft rolling tool chest / 1 lab styled counter work station with stool seating / 1 4ft x 4ft rolling work table / ceiling hung climate control unit

Behavioral Considerations
The majority of the bays must maintain a minimum of 20ft ceiling clearance with full height overhead door access.

Structural Systems
The structural system of the research bays must be able to handle shifts in temperature and exposure to the elements that may be experienced in the testing stages of development.

Mechanical / Electrical Systems
The mechanical and electrical systems of the labs must have the ability to handle multiple independent loads if required for testing or assembly.

Site / Environmental Considerations
The bays must have access to the loading dock and should maintain lower public profile.
### Quantities Required

1-5 person occupancy
1 space
2,100sf net area
2,100sf total net area

### Purpose/Functions

The shop will act as a servant to the needs of the research bays producing specialized elements in-house. The machine shop should maintain a low profile but easily accessed when need by any of the individual research bays for certain parts or modifications.

### Activities

The shop will house the machining of any specialized parts.

### Spatial Relationships

The shop should be located centrally to all of the research bays.

### Special Considerations

Lighting levels within the shop must be optimal for precision machine working.

### Equipment / Furnishings

- CNC Machine Router 8ft x 10ft x 8ft
- CNC Lathe 7ft x 4ft x 4ft
- CNC Milling Machine 6ft x 8ft x 6ft
- CMM (Coordinate Measuring Machine) 3ft x 3ft x 6ft
- Injection Molding Press 3ft x 3ft x 6ft
- Grinding Station 3ft x 3ft x 4ft
- 2 CAD Workstations

### Behavioral Considerations

The shop will require extra sound insulation systems to maintain tolerable sound levels in other areas of the building.

### Structural Systems

None

### Mechanical / Electrical Systems

The shop will need to maintain proper cut cooling oils as well as proper disposal and scrap material reclaim systems. Both shops require a combination of both two-phase and three-phase electrical systems.

### Site / Environmental Considerations

None
Quantity Required
Education / Meeting Hall
20 Person Occupancy
3 Spaces
600sf Net Area
1,800sf Total Net Area

Purpose/Functions
This area shifts from private to public function to meet the requirements of the facility. Housing a collection of people this space will begin to mimic the functions of the auditorium on a personal scale.

Activities
The spaces will house face to face meetings; it will also host external education programs which embrace the ideas of energy conservation and general green design courses.

Spatial Relationships
The rooms should be located so that they act as both a resource to the office areas but also so that they remain accessible to the public groups who come to attend the classes that will be held in the rooms.

Special Considerations
None

Equipment / Furnishings
Two large meeting tables / thirty chairs / a digital podium station / classroom scale projection system

Behavioral Considerations
The rooms should maintain a near equal length to width ratio as to avoid pushing any visitor out of ear shot of the speaker.

Structural Systems
None

Mechanical / Electrical Systems
Digital projection or display units

Site / Environmental Considerations
The learning environment could benefit from natural lighting but should have the ability to block it out for projected presentations. The spaces should also have visual connections with the buildings exterior and or greenhouse.
OFFICE SPACE

QUANTITIES REQUIRED
- 25 person occupancy
- 1 massed space
- 4,200sf net area
- 4,200sf total net area

PURPOSE/FUNCTIONS
The private office space will house the initial steps to the development of new technologies. Maintaining an adaptable program that can shift between individual research to collective research environments. The office space will also need to accommodate independent study and research. The space must also retain the ability to grow and shift with the work load and staffing of the office.

ACTIVITIES
The space will house the desk and computer research plus the computer aided design work of the new technologies elements. The space must also offer space for reception and an office support area.

SPACIAL RELATIONSHIPS
The office space needs to be located where it can acquire new floor areas without causing addition area shortage problems.

SPECIAL CONSIDERATIONS
The office should be located to accommodate extra space with the flux in the research and design elements of the practice.

EQUIPMENT / FURNISHINGS
- 24 office sized desks / 24 computing chairs / 10 desk top computers / 15 notebook computers / a copying machine and office supplies storage cabinets

BEHAVIORAL CONSIDERATIONS
None

STRUCTURAL SYSTEMS
None

MECHANICAL / ELECTRICAL SYSTEMS
The mechanical systems will require an AC system capable of maintaining the proper temperature level for the computers to work at maximum capacity, and provide a healthy environment.

SITE / ENVIRONMENTAL CONSIDERATIONS
The office space will want to be careful not to pull excessive amount of natural lighting into the zone as to avoid glare on the computer screens.
QUANTITIES REQUIRED
1-10 person occupancy
1 space
1,200sf net area
1,200sf total net area

PURPOSE/FUNCTIONS
The Kitchen will serve the private sector providing both food and snack preparation plus a small eating area with excess numbers using the lounge space.

ACTIVITIES
The space will house the preparation of minor meals and food consumption in for a small group.

SPACIAL RELATIONSHIPS
The space should maintain proximity to the office and lounge section of the building while allowing overflow to spill into the lounge area.

SPECIAL CONSIDERATIONS
As this room will function primarily as a lunch preparation room it should be positioned to receive its maximum day light during the 11-1 time period.

EQUIPMENT / FURNISHINGS
25 linear feet of upper, lower cabinets, and counter space including 2 double basin sinks / 2 large 3ft x 30in x 6ft refrigerator / 3ft x 3ft x 4ft oven stove set up / one microwave unit / 2 large luncheon conference tables / 40 chairs

BEHAVIORAL CONSIDERATIONS
None

STRUCTURAL SYSTEMS
None

MECHANICAL / ELECTRICAL SYSTEMS
None

SITE / ENVIRONMENTAL CONSIDERATIONS
The room should be positioned toward solar noon to allow the maximal effects of the sun during the lunch break shifts.
PRIVATE RESTROOM

QUANTITIES REQUIRED
- 6 PERSON OCCUPANCY
- 2 SPACES
- 250sf NET SPACE
- 500sf TOTAL NET AREA

PURPOSE/FUNCTIONS
- A HIDDEN ROOM SERVING THE INDIVIDUAL FUNCTIONAL NEEDS OF THE EMPLOYEES OF THE FACILITY

ACTIVITIES
- THIS ROOM WILL ASSIST THE DIGESTIVE NEEDS OF THE HUMAN ELEMENT OF THE BUILDING

SPACIAL RELATIONSHIPS
- THE ROOM SHOULD BE LOCATED NEAR THE OFFICE SPACE AND THE MAJORITY OF THE BUILDINGS EMPLOYEES. THE ROOM SHOULD BE EASILY LOCATED BUT POSITIONED AS TO AVOID DISRUPTING OTHER FUNCTIONS.

SPECIAL CONSIDERATIONS
- None

EQUIPMENT / FURNISHINGS
- EACH ROOM WILL HAVE THREE STALLS WITH THE EXCHANGE OF ONE URINAL FOR ONE OF THE STALLS IN THE MEN'S ROOM / BOTH ROOMS WILL ALSO CONTAIN TWO WASH BASINS

BEHAVIORAL CONSIDERATIONS
- THE SPACE MUST BE DESIGNED WIDE ENOUGH TO ACCOMMODATE 5FT STALLS AND PASSAGE PAST THEM.

STRUCTURAL SYSTEMS
- None

MECHANICAL / ELECTRICAL SYSTEMS
- THIS SPACE SHOULD BE DIRECTLY VENTILATED TO THE BUILDINGS EXTERIOR.

SITE / ENVIRONMENTAL CONSIDERATIONS
- None
Quantities Required
0-5 person occupancy
1 space
3,000sf net area
3,000sf total net area

Purpose/Functions
This space is a private space that accommodates the functions of the research labs. The function is a collective intermediary servant between the shipping dock and research bays.

Activities
The storage of materials and products of the research

Spatial Relationships
Should be located by the research bays.

Special Considerations
1 electronic forklift / 8 4ft x 10ft steel storage racks

Equipment / Furnishings
The room requires a minimal ceiling clearance of 20ft

Behavioral Considerations
None

Structural Systems
None

Mechanical / Electrical Systems
The room must be able to accommodate a charge station for the forklift.

Site / Environmental Considerations
The storage bay should be located near the shipping and receiving area on the site.
**Quantities Required**
- 0-2 person occupancy
- 3 spaces
- 900sf net area
- 2,700sf total net area

**Purpose/Functions**
The room serves the building invisibly creating an internal climate that the building is unable to achieve on its own.

**Activities**
None

**Spatial Relationships**
The room can be located out of the way of other functions but should be located near the center of the building section it serves. Assembly / Research / Development.

**Special Considerations**
None

**Equipment / Furnishings**
Multiple zone HVAC unit

**Behavioral Considerations**
None

**Structural Systems**
The floor system of the room must be able to support the room's equipment.

**Mechanical / Electrical Systems**
The room must meet the electrical requirements

**Site / Environmental Considerations**
Exhausting should be located on the roof of the building while intake should be positioned to pull in cool air in from beneath the building.
DESIGN GOALS

The idea behind adaptive architecture is to follow the example set forth by nature to prolong the functional use of buildings.

By breaking down existing adaptations into their basic features it becomes possible to draw on the functional element of that adaptation. Taking these elements and using them as building blocks for architectural ideas, architecture inherently becomes more functional in a constantly changing world. The design phase applies the ideas derived from the precedent study phase to the environmental elements: light, ventilation, hydrology, and volume. These four aspects of environment are addressed in the following designs as they progress to a conclusive design proposal.
Site inspiration began with a concept that a building be derived directly from site form. The first sketch attempts this by pulling both building and site into geometric form for a better comparative analysis of the two objects. The second two sketches begin to examine form based solely off the wetlands that are the primary feature of the site.

Adaptive approach to design began by quantifying a series of changes and how a building could address them. Each adaptive concept that was pursued was then broken down into a single identifiable sketch to reference each idea to a collective whole.
FOCUSING ON HUMANS' ABILITY TO SWEAT, THE FIRST DESIGN BEGAN TO LOOK AT THE CONCEPT OF RUNNING WATER DOWN THE SIDE OF A BUILDING TO BEGIN TO AID IN COOLING AND THE POSSIBLY OF ALSO CREATING INSULATING PROPERTIES WITH THE FORMATION OF ICE.

This initial concept was developed from the rotation of a sunflower's head. This concept began to look at the possibilities of using a passive hydraulic system, charged by the sun, to operate different adaptive shifts around the building.

The concept that water could be used to insulate a building during winter seasons refocused the concept, pulling the water element away from the facade. This idea began to produce a double facade concept as water created an outer ice shell protecting the building through a natural occurrence.
The initial adaptation that began to formulate these sketches was the shift that a boat's sail is required to make in heavy winds. This thought led to the basic development of a screw and torque system that could drop a level of a building. Using a high bay area and allowing it to drop to a single story could reduce the amount of facade that the elements could impact. This concept also began to create new exterior spaces during inclement weather.

The idea of using a folding deck meant to increase the area of a building by drawing up a collapsible system that can be fixed to the side of the building. During pleasant weather the collapsible room could then be lowered creating access to an outdoor area which could begin to serve the functions of the building.
Maintaining a focus on wind conditions, this scheme begins to address an adjustment in the external shape of the building. This concept allows a building to block or draw on both wind and solar exposure of the building.

Applying the idea to an actual building scheme, the system becomes focused on adapting more vulnerable elements of the building façade. The pictures to the right show an application at the entrance to a building scheme creating both an environmental adaptation and an interactive entrance element.
This final initial scheme consists of a louver system at the end of several wings, giving the system the ability to scoop wind from any direction. This provides the building with ventilation no matter which way the wind is blowing.

Combining this system with a convection system powered by green houses around the building, ventilation becomes almost completely passive.
The focus behind these designs was to create an awareness that human presence has an effect on the environment.

The concept was approached through the design of a bridge system that could either allow the human to pass or the environment beneath to thrive.
THE FINAL WETLANDS BRIDGE SEEKS TO REINFORCE THE HUMAN'S IMPACT ON THE WETLANDS AS THE PATRON CROSSES BY CREATING A NEW ENVIRONMENT WHICH HE NOW HAS TO PASS THROUGH TO REACH THE OTHER SIDE. AS THE BRIDGE UNFOLDS TO ALLOW THE PATRON TO CROSS IT EXERTS A SHAD ED ENVIRONMENT ON BOTH THE WETLAND AND THE PATHWAY.
The initial concept was to find a way that a cubical could operate both as an individual cell or adapt into a collective work unit. The final cubical design allows for its occupant to choose the appropriate level of seclusion based on the work he or she is engaged in. This can be accomplished either by positioning the slidable partition wall or by manually removing the small tiles from the partition wall creating new view corridors for the worker.
This concept focuses on the idea of volume shifting and expanding floor space within the building.

(Above) A simple sketch model displays the possibility of multiple floors sliding in and out of an exterior wall.

(Left) A hydraulic arm pushes each floor to increase floor space and is balanced by an elastic material window. (Also portrayed in the concept sketch)

(Right) Walls slip in and out of static floor system which can then be used to disperse excess heat.
This design concept employs multiple units per floor which could be shifted on tracks consuming space from one function of the building to supplement another. (Plan diagram left with sections below)
Water runoff and erosion are significant factors on the site. The concept behind these designs were to retain water on the structures roof to be released in drier weather as to avoid excess erosion during rains.
Building form first emerged from a series of block massing models to determine the most beneficial form for the site and building.
A series of parti diagrams began to further investigate the feasibility of certain schemes on the site in quick iterative steps.
Three different form ideas projected vertically to a two dimensional plane then pulled back into three dimensional form attempting to maintain stronger connection to the ground plane.
(LEFT) Sketch sections that begin to further depict vertical elements of the building form.

(BELOW) A sketch concept that began to think about form and its contact to the site through foundation.

(BELOW) Early water color rendering of the buildings section.
(right) Several design concept models that begin to study how the shape and reach of the building will begin to affect the site.

(below) A study model with its projected roof and floor planes and a brief study of its interaction with the green houses in the project.
The mid-point form was designed thinking about the site's:

- Hydrology, collecting all roof runoff along the building's spine.
- Wind, harnessing by use of positive pressure corridors and expanding wings.
- Solar energy, maximizing southern facing facades and directional green houses.
The shading studies (left) show the early stages of the first programmatically developed building form. The resulting form (below) shows the plan layout of the building and its circulation.
The sections (below) show cuts through the first formal building proposal for the thesis. These sections are through the four distinct elements of the building with a final cut connecting the building elements.
The matrix (left) shows various conditions developed by a building. Each conditional opportunity (marked in green) was then converted into a sketch and techniques.
These massing studies show the lighting conditions created by both the daily and seasonal cycle of the sun.

- Take note of the greenhouse lighting differences between summer and winter (left).

- The plan views (below) show how the building mass begins to effect the lighting of the site around it throughout the day.
This model was a large scale study of the proposed greenhouse space and its interaction with the surrounding building.

(Starting top right)
- View into greenhouse from a research bay.
- Ground view down proposed scissor lift track.
- Ground view Southeast of the greenhouse.
- Eagle eye view Southeast of the greenhouse.
- Eagle eye view Southwest of the greenhouse.
The final proposed building seeks to culminate the thesis into a physical architectural form.
Hydrology

Issues

The wetland located on the south end of the site is the primary headwater for the miller creek tributary to the Huron river. In recent years, new local developments and impervious surfaces have increased runoff into the wetlands to numbers reaching millions of gallons. This drastic increase in flow has lead to a growing problem of erosion and sediment in miller creek and the Huron river.

Goals

- Prevent any further increase in site erosion rates due to rainwater runoff.
- Redistribute rain water blocked from the site back across the site.
- Retain water inside the building to assist in thermal lag.
- Maximize the water ability to reflect high level of light.
- Minimize water flow and erosion across the Northwest end of the site.
Water shed from each distinct roof structure is distributed across the site for future irrigation.
Rainwater runoff is piped down into an open top canal system acting as a thermal sink for greater lag between night and day.

Surface reflection of the canals provides increased amounts of natural lighting to shaded areas of the building.

Excess canal water is overflowed into subsequent canals stretching down the sloped site toward the wetland. The canals would be released, by a passive solar charged hydraulic system, into one of the on-site gardens.
**Issues**

Southern Michigan has a full seasonal change requiring both heating and cooling for its inhabitants. Although heating is the dominate concern, warm summer days and high internal heat loads create a necessity for cooling buildings. Due to the site's open qualities solar gain can be maximized but during the summer the site lacks solar shade.

**Goals**

- Maximize solar heat gain during winter months.
- Minimize solar heat gain during summer months.
- Create thermal lag between day and night functions.
- Use solar gain to assist in stack effect ventilation.

Shading devices span over the expanses of the greenhouse limiting them solar gain to the greenhouse in the summer. The shading devices are angled to block the majority of the summer sun while allowing the winter sun to heat the greenhouse. During cooler summer months the shading devices can be retracted to maximize thermal gain.
The green house acts as the thermal sink of the building. The two canals located within the green house create a thermal lag which begins to regulate the building's temperature between night and day. This gained heat can then either be vented out the roof of the green house or back through the facility.

During the winter months the external louvers of the public wing of the building can be rotated shut producing a double facade. The new cavity of solar heated air acts as an insulator between the internal and external environments.
**Issues**

Weather affects our daily routines and practices from an hourly to an annual cycle. The common building deals with these changes by simply repelling or overpowering the condition. This scenario allows humans to easily ignore the impact that their luxuries are having on their environment. This ignorance has lead to a level of damage that is rapidly becoming dangerously irreversible.

**Goals**

- Create spaces where secondary functions begin counter the effects of their primary functions.
- Raises awareness of the impact and damage that can be caused by daily routines.
- Design a flexible program that can conform to the needs of the program function.
- Create an environment where multiple technologies can be tested simultaneously.
- Conform the building to meet the various needs of the occupants.
During the summer months visitors would park cut in the site and traverse the property to the entrance to the building. During the winter months parking would be located under the the research wing of the building. The porous grate site parking lot could then be planted with winter rye which would begin to cleanse the lot soil. In early spring the lot could be harvested and summer parking would resume.

The wetlands bridge was designed as a draw bridge between nature and man. As the bridge rotates open blocking light from the wetlands it conjointly casts a shadow on the user. This begins to raise awareness to the impact that the most benign activities have on the environment.
The building pods serve two primary purposes for the facility. Their primary function is as a mobile research and testing facility. With bolt on construction techniques new facades can be placed and monitored across the site. Secondly the pods have a generic facade which can be attached and used to expand building to conform to the facilities work load.

The cubical are design to be as flexible to privacy as possible. With modular B" units the cubical wall can be as tall or short as desired. Once constructed the wall can rotate to enclose or open the occupant to the environment. The wall is also designed with a grid of tile which can be remove or installed to create new view corridors or offer seclusion.
Research has proven that natural light has positive effects on the working and learning environment. Ann Arbor, Michigan has a steady cycle of day and night, ranging roughly six hours of sun light between summer and winter. In the day the open site offers an even spread of day solar lighting with the exception of the south and west property lines of the site during the winter months.

**Goals**

- To provide the building with a maximal amount of functional natural lighting.
- To incorporate a system of combined natural and artificial lighting.
Incorporating a translucent wall with the building west facing wind wall allows the elimination of excess light and heat gain while the building is unable to passively ventilate the area.

The library skylights are designed to work as a passive and active lighting system. During the day, the opening allows natural light to flood down into the library. At night, spotlights located in the fixture provide up-lighting illumination for the greenhouse.
The auditorium incorporates back lit natural lighting to avoid direct eye exposure to bright light during room illumination. This system also allows maximal control of natural light infiltration with a minimal amount of glare at the front of the room.
Ventilation

Wind Roses
The wind roses show monthly wind directions, duration, and intensity based on a compass rose layout. The duration of the wind is displayed by the length of each bar while intensity is measured in meters per second represented by the color of each bar for each month.

Issues
Prevailing winds move across the site from the southwest. The majority of this wind is channeled through two primary breaks in the tree line, marking the site's south and west border. These breaks create points of higher velocity producing points of high potential.

Goals
- Direct the wind to cause natural air changeovers in the building.
- Compress and decompress wind entering the building to allow natural cooling of the building.
Located near a break in the site’s encasing tree line, the western facade incorporates a system of louvers which are able to collect the prevailing winds into the wall’s cavity and across the building providing natural cross ventilation.
The gables of the green house roof are skewed to the west channeling wind down its valleys and into the building on the far side. This system is assisted by the shading sails which begin to funnel wind down into the roots low points.

As wind (accelerated by green house roof) hits the wall of the auditorium it is forced up through the vents evenly and is released near the room's ceiling. On the far side of the room a second perforation exists allowing the rising heat to be swept from the room. This system allows for natural air change over while minimizing light infiltration into the room.
Louvers in the floor of the exhibition hall allow the room to draw cool air up from beneath the building by means of natural convection. This system can also be assisted by the stack effect ventilation created by the room's double facade.

Providing references to Calatrava’s previous projects, the Kuwait Pavilion adapts to the different uses between night and day.


The basic history and botany of the cactus, addressing the variety of different cacti and some of their adaptive techniques.


A critique of modernism in Germany in 1926, focusing on the differences between functionalism and rationalism.


Focusing on the transformations of buildings, “How Buildings Learn” refers to how buildings change once the initial construction has been completed. These building alterations begin to mimic the adaptive response under pinnings focused upon by my thesis.


Glass is presented facades are presented in different innovative ways including several double facade buildings that actively and passively adapt to internal and external heat loads.

A general anatomy and history of the underwater cow (hippopotamus) addressing some misconceptions about the large underwater animal.


Tall buildings deal with their external environments with numerous facade ecological designs. These designs that adapt buildings to the environment are integral elements to the adaptive building.


A journal dealing with how building can be de-constructed and reused to minimize waste of a building


Digital renderings of the pavilion over the new wing to the museum show Calatrava’s desire to keep the buildings kinetic features light and inspiring rather than a heavy shifting element.


Most books addressing Calatrava’s Quadracci Pavilion were published during or prior to the project’s completion. Kent’s book written after the project’s completion not only contains floor plans but speaks about the project first hand rather than through theory.

Offering reference to older Calatrava kinetic buildings such as his Kuwait Pavilion of Seville, the book speculates the effects of Calatrava's perceived Milwaukee project based on preliminary models and sketches.


The adaptability of items from umbrellas to ladders, adapt to create some form of space whether to store or travel each object compacts itself through a different combination of mechanical adaptations.


A run through of the basic needs of survival which in turn become the basic reasons for adaptation.


A simplistic bug encyclopedia, giving descriptions of numerous bugs.


Some reptiles of the past use to have sail like fins on their back which they could redirect their blood through to regulate their body temperature.


A catalog of the work of Pekka Helin and his technologically advance building designs.

The history of the Space Needle and it close brush with its demise, ultimately referring to its technical aspects.


A theory on adaptable architecture through the idea of bolt able architecture.


A theory on the art experience influences human perception positively and its affects on society today.


Discussion and critique over the globalization of architecture and the idea of the box building.


A listing of some of Uni-Systems more technologically advanced architectural projects both built and conceptual.


Addressing the issue of natural selection referencing the writings of Darwin and his three points of adaptation.