*It is early afternoon on a summer day. You are eating lunch under a pavilion. The weather seems pleasant, but you are aware of a subtle motion in the pavilion's enclosure. The edges begin to rotate towards the ground as the light apertures narrow protecting you from a strong gust of wind that will soon blow a storm your way.*

## RESEARCH PROPOSAL

A deployable shelter finds it shape in the form of environmental mimicry, taking cues from wind speed, temperature, and humidity. The shelter is a prototype for a system that can create a loop of information and action between the structure, the environment, and its inhabitants with subtle motions and changes in light and atmosphere. The shelter attempts to make visible connections between natural and artificial environments and their occupants in ways that are usually unrealized through visualization and interaction. The form of the shelter becomes a collaboration between the inhabitants and the environment.

We propose to study the integration of intelligent computing and active structures as two interdependent factors in the built environment. Recent design research projects have applied pervasive computing as ambient media that is a secondary system to built structures. There have also been a number of research projects, such as Peter Testa's Carbon Tower, that have studied the integration of dynamic structures as large scale mediators within the built environment. However, these projects study the implications of such technologies as independent to one another. We believe that applying pervasive computing and active structural technologies independently undercuts the potential of each to create a dialogue between people, buildings, and the environment. We intend to study an integrative approach which implements intelligent computing and ambient media at the scale of the structure.

We propose to realize these technologies at the human scale to study their affect on the situational context of the surrounding environment by developing a prototype for a shelter that senses and responds real-time to environmental conditions, such as heat, wind, and humidity. The structure-as-skin system will incorporate "Shape Memory Alloys" and ambient information systems that will make a visible connection between climatic conditions of the natural environment and spatial conditions of the built environment that can be understood by casual users. The interaction of inhabitants with the dynamic structure will be enabled by the communication of the environmental sensors to the SMA actuators that will physically alter the structure. We hope to develop a system that goes beyond surface integration and sets up the potential for learning patterns between the user and the environment.

"Shape Memory Alloys" (SMA), are particularly relevant and underutilized in their potential application to the built environment. SMA is an extremely lightweight, low-profile, and strong material that can generate large forces when actuated with heat. A significant amount of research is currently being done at the University of Michigan in how to incorporate this material into aerospace structures, such as satellite and plane design, and medical implants, such as artificial hearts, to simulate muscle motions. Research is also being done on how to incorporate SMA into buildings and bridges to prevent destruction by vibrations. However, little research has been done on how to incorporate SMA technology into built structures at a scale that impacts the inhabitant on a daily basis.

This project raises questions such as:

1) How can technology operate as a peripheral experience to architecture while still being immediately intelligible to the inhabitants?

2) What are the formal implications of dynamic and smart materials, such as SMAs, on the built environment? What are possible implications at the scale of the city?

3) How does the integration of ambient media and dynamic structures affect the way people engage architecture? Does it make the connection between the built environment, the natural environment, and its inhabitants more vivid?

4) What other spatial prototypes can this system generate? How can this system of computational intelligence be integrated with other systems, such as photovoltaics, to produce greater environmental benefits? How can such systems be retrofitted to existing infrastructure?

## LITERATURE REVIEW

**Prototyping the Future**
**Asymptote** (Current Exhibition, Venice Biennale of Architecture)
http://www.archiportale.com/News/schedanews.asp?idDoc=12608&iDCat=49
The studies of fluid dynamics and ballistics were imposed onto three different built forms. The resultant objects touch on architectural possibilities that result when form is subjected to science. In their site context, the objects are agents of spatial interference, absorbing and retransmitting the space of their surroundings into textural and ambient constructs for potential occupancy. As a practice, Asymptote has put into question the boundaries between architecture, engineering, and art and examines how those possibilities can be explored using digital fabrication and rapid prototyping. Asymptote encourages architecture and engineering to influence each other, instead of the usual practice format where one discipline works to further the goals of the other.

**Hyperhabitat: Reprogrammning the World**
**Vicente Guallart, Daniel Ibanez, Rodrigo Rubio** (Current Exhibition, Venice Biennale of Architecture)
http://www.hyperhabitat.net/
Hyerhabitat: Reprogramming the World is a research project that explores the potential of information to organize the habitability of the world. The project posits the need to reprogramme the structures with which we inhabit the world through the introduction of distributed intelligence in the nodes, networks and

environments with which we construct buildings, cities and territories. The project incorporates digital manufacturing, the creation of Internet 0 (a micro-server technology developed at MIT to generate ambient intelligence by linking miniature computers) and the theory of the multiscale habitat, an 'urban genome' project developed at IaaC that seeks to introduce new approaches to the generation of buildings and cities by restructuring the functional relationships between the constituent parts.

**Galleria Fashion Store**
**UNStudio w. Arup** (Seoul, September 2004)
http://www.arup.com/netherlands/newsitem.cfm?pageid=6693
The building facade uses LEDs, fiber-optics, and reflective materials to create a perpetually changing, light-reactive and computer programmable radiant surface. Although these technologies are not new to this building, this was the first time the technology was employed at such a large scale. In this situation, ambient media is applied as a passive method of information that only allows one direction of transmission and receipt. We would like to co-opt the technology used in this building and integrate it into a system that allows for a two-way interaction.

**Carbon Tower**
**Peter Testa Architects** (October 2003)
http://archrecord.construction.com/innovation/2_features/0310carbonfiber.asp
The Carbon Tower Prototype is a 40 story cylindrical mixed-use high-rise that incorporates a precompessed double helix structure with a breathable thin-film membrane. The building floors are strung together by 40 carbon-fiber strands that measure 1 inch wide by 650 feet long. The building uses active lateral bracing, sensors and actuators imbedded in the buildings structural fiber, that tighten the outer skin in response to wind load.

**Greenfield, Adam and Mark Shepard. Architecture and Situated Technologies #1: Urban Computing and Its Discontents**. Lulu Publishing, Fall 2007.
The Situated Technologies Pamphlet series explores the implications of ubiquitous computing for architecture and urbanism: How is our experience of the city and the choices we make in it affected by mobile communications, pervasive media, ambient informatics, and other "situated" technologies? How will the ability to design increasingly responsive environments alter the way architects conceive of space? What do architects need to know about urban computing and what do technologists need to know about cities?

**Greenfield, Adam. Everyware: The Dawning Age of Ubiquitous Computing**. Indianapolis, IN: New Riders, 2006.
The age of ubiquitous computing is here: computing without computers, where information processing has diffused into everyday life, and virtually disappeared from view. This book is an attempt to describe the form computing will take in the next few years. Specifically, it is about a vision of processing power so distributed throughout the environment that computers per se effectively disappear. This book explores

the consequences this disappearance has for the kinds of tasks computers are applied to, for the way we use them, and for what we understand them to be. What does this mean to those of us who will be encountering it? How will it transform our lives? How will we learn to make wise decisions about something so hard to see?

**The Design and Experimental Validation of an Ultrafast Smart (SMA Resettable) Latch** (November 11-15, 2007)
2007 ASME International Mechanical Engineering Congress and Exposition
John A. Redmond, Diann Brei, Jonathan Lutz (University of Michigan, Mechanical Engineering Department)
Alan L. Browne, Nancy L. Johnson, Kenneth A. Strom (General Motors Research Laboratory)

Latches are an essential machine element utilized by all sectors (medical, military, industrial, etc.) and there is a growing need for active latches with automatic release and reset capabilities. Shape memory alloy (SMA), due to its high energy/power densities, is an attractive alternative actuation approach to conventional methods (electrical, hydraulic) because it is inexpensive, lightweight, compact and has a fast heating response times. This paper introduces the T-latch which is based upon a compact spooled SMA rotary actuator. The T-latch can engage passively, maintain a structural connection in multiple degrees of freedom with zero power consumption, actively release very quickly (< 20 ms) and then repeat operation with automatic reset. To provide the basis to apply this latch across sectors, operational behavioral models are summarized for the key states of engagement, retention, release and reset. To demonstrate the technology, a proof-of-concept prototype for automotive panel lockdown was designed, built and experimentally characterized for the basic operational states along with studies of the effects of power, seal and reset force. The results from this study indicate promising suitability of the T-latch technology for a broad range of industrial applications.

**US Patent 6170202 - Building System Using Shape Memory Alloy Members** (Issued January 2001)
http://www.patentstorm.us/patents/6170202.html
A system and method is described by which the structural integrity of a building or other structure can be increased and made more resistant to earthquake damage. At least a portion of a structural member is made of a material that undergoes a shape or phase transformation in response to energy applied. This member can alter the natural frequency of the building structure to make destructive resonance less likely to occur.

THE WRAP/PROJECT OBJECTIVES

We have two primary objectives for the tangible output of this project:

1) Develop and fabricate an approximately 2.5 meter by 2.5 meter working prototype of a deployable shelter which will include:

- Designing a network of sensors that integrates with a micro-controller embedded within the structure

- Developing a deployable dynamic structural system that utilizes the formal potential of Shape Memory Alloys

- Integration of other dimensions of ambient media output, such as LEDs, into the structural system and enclosure

- Fabrication using digital technology and rapid prototyping

2) Install the prototype into various spaces and study the interaction between the structure, the environment, and its inhabitants.

In addition to the tangible output, we intend to use this opportunity to answer questions raised in the project proposal.

## SPECIAL EQUIPMENT REQUIREMENTS

A significant portion of the Grocs grant will go towards the purchase of materials to build the structure. We will purchase various sensors and circuits to develop the network system and micro-controller. The structure will require the purchase of SMA wire, although, the exact materials that we will use in construction of the structure will be determined as we move closer to a final design. In addition to physical actuation of the structure, a large portion of the ambient media output will require the purchase of LEDs. Although we are not currently in possession of these materials, we are aware of how to acquire them and the costs/quantities involved.

## THE TEAM

Collaboration between architects and engineers has traditionally been a one-way operation where half of the group is in service to the other. We propose a two-way model of collaboration where architecture and engineering work with digital models and information shoulder to shoulder. Since the submission of the initial abstract, which was written before the architecture side of the team had found their engineering counterparts, the project has evolved. Our individual knowledge and expertise has had implications on the direction of the design and its intent. The engineers have brought technological and structural creativity which the architects have implemented strategically to develop an idea for a prototype that studies the implications of pervasive computing and active structures as two interdependent factors in the built environment. Neither the architecture nor the engineering program has an outlet for two-way collaboration.

We believe that this form of collaboration is vital for keeping architecture relevant to the future and for keeping engineering tangible at the human scale.

*University of Michigan, Taubman College of Architecture and Urban Planning*
**Kendra Byrne** came into the M. Architecture program with a bachelor degree in Communication Studies that focused on the give and take of sociological interaction. She also has experience with digital fabrication and rapid prototyping. **Evan Hall** is currently a 2nd year M. Architecture student and has a bachelor degree in studio art with a focus in light sculpture, specifically using color and light to define space. In addition to projects dealing with the construction of the built environment, both Evan and Kendra have been involved in developing and building ambient and tactile sensory environments (using the Arduino microcontroller) in the Taubman college.

*University of Michigan, College of Engineering*
**Brendan Byrne** is a 3rd year undergraduate student in the Aerospace Engineering program. He has experience in designing dynamic structural systems and is currently involved in designing and building information networks for satellites in the Student Space Systems Fabrication Laboratory. **Brent Utter** is a 3rd year direct Ph.D. student in the Mechanical Engineering Department. His research is in the development of a fully implantable medical device for treating short bowel syndrome. The device interfaces force and displacement sensors with "Shape Memory Alloy" (SMA) actuators, using a microcontroller, and transmits data to surgeons via a 433MHz wireless communication link.

We have the skills, knowledge, and confidence to design and fabricate the proposed system as a team. Through our discussions we have developed concepts for potential dynamic structural systems and have examined possible methods of integration with ambient media and the environment. We are hopeful that this project will open up doors for future collaboration between architects, engineers, and other fields of study such as sociology and natural resources. We are looking forward to receiving support in our efforts to study how such systems can perform to create a better environment.