INTERACTIVE MEDICAL EMERGENCY DEPARTMENT
ARCHITECTURAL INTEGRATION OF DIGITAL SYSTEMS INTO THE EMERGENCY CARE ENVIRONMENT
This thesis entitled "The Interactive Medical Emergency Department (iMED): Architectural Integration of Digital Systems into the Emergency Care Environment" prepared by David Benjamin Ruthven was presented to the Graduate School of Clemson University in May 2007 in the form of a verbal defense and written manuscript. The research and project were completed in order to fulfill the requirements of the Architecture + Health program at Clemson University, as well as of the AIA/AAH 2006-7 Arthur N. Tuttle Fellowship, and will be presented at the 2007 AIA/AAH Fall Conference in Dallas, TX. The project was also featured at the criticalMASS conference at the University of North Carolina at Charlotte in April 2007 and was awarded the 2007 Healthcare Environment Award in the student category.

Clemson Thesis Committee // Fellowship Committee // Research Support

David Allison, Major Advisor // Willy Schlein // AIA Foundation
Jose Caban // Jason Schreor // AIA Academy of Architecture for Health
Keith Green // Callison Architects
John Jacques // HKS Architects
Kuang-Ching (KC) Wang // Dina Battisto, Clemson University
ABSTRACT

In healthcare, the architectural response to the development of information technologies (IT) has largely been relegated to a reactive role, essentially waiting for systems to evolve and simply accommodating them with appropriately sized spaces. Designing IT systems independently from, rather than integrally with, their environment impedes them from reaching their full potential as vital components in the delivery of care by creating a lack of flexibility, decelerating performance, and degrading the healing environment. Dissolving the disconnect between the physical environment and information technology systems can be achieved by devising architectural elements and treatment protocols which would fuse both entities together, creating a more holistic, digitally integrated setting in which to deliver care. The emergency care environment was selected as an appropriate vessel to implement the thesis, due to its need for flexibility in order to accommodate ever changing demographic needs, significant volumetric shifts (especially during mass casualty events), fast paced care delivery which is dependent on the rapid utilization of information, and high patient turnover rate requiring efficient throughput processes. The fusion of digital modalities with architectural elements in the emergency care environment could remediate problems relevant to contemporary emergency departments, including overcrowding, staffing issues, and inability to accommodate for volumetric surges, by improving the overall throughput of the facility.

To ensure the final design holistically satisfies the goal of improving the quality and effectiveness of emergency care through the environmental integration of information technology, a series of design principles were developed to serve as its basis. The programmatic typology of a freestanding medical emergency department, in which there is no connection to an existing facility, was selected with the intention of deriving a pure condition which eliminated extraneous influences from diluting the focus of this thesis on the relationship between information technology and architecture. The proposal consists of a freestanding, 40,000+ square foot Interactive Medical Emergency Department (iMED) located in Charleston, SC. The proposal was guided by the established set of design principles, aiming to improve the delivery of emergency care during daily operations and mass casualty surge events through the architectural integration of information technology.
An increase in the availability and quality of healthcare providers during the early 20th Century, coupled with growing population rates in the United States, lead to the realization that recording, organizing, and retrieving information was critical to the effectiveness of care delivery. A paper based recording system evolved as a result, fundamentally reshaping the layout and organization of the healthcare environment. It was not until the last quarter of the century that digital technologies would create a paradigm shift in information utilization within healthcare, redefining the methodology in which the delivery of care was conducted (Ball, 27-35).
A BRIEF HISTORY OF INFORMATION UTILIZATION IN 20TH CENTURY HEALTHCARE ENVIRONMENTS

PC in Hospitals
- Decentralized Workstations
- Digital Point of Care Charting
- 1980's Widespread Computing

Mobile Computing
- Computer on Wheels
- 1990 1st 'Notebook' Computer

Internet
- Internet Expands Connectedness
- WebMD

Wireless Connection
- Telemedicine
- RFID
- 2000 Ubiquitous Computing

As the turn of the 21st century approached, personal computing modalities and advances in telecommunications rendered the paper based recording system obsolete, dramatically improving the availability, accessibility, and usability of data within caregiving environments. However, the healthcare industry still largely remains dependent on a hybridized paper/digital system for several reasons, most notably the lack of overall funding that is allocated for IT implementation (a mere 3% as compared to 10% in banking for example) [Davis, 04].
As the methodological paradigm shift from a paper based system to its digital successors unfolds, the fundamental role of healthcare architecture has remained in the same state it was when paper records were employed: reactive. The physical environment has been relegated to an afterthought, simply waiting for technologies to develop and methodically accommodating them within appropriately sized spaces when called upon. Implementing a myriad of IT systems within a healthcare setting without any real integration into their environment creates a disconnect that inhibits each from optimizing their full potential as critical components in the delivery of care.
The disconnect between healthcare environments and information technology systems hinder the caregiving process by compromising the ability to adapt to changing conditions, administer care with optimum efficiency, and provide a suitable healing environment for improved patient outcomes.
Mobile computing modalities coupled with medication dispensing systems increase the moveability of systems, but are limited by their size, dependency on power sources to recharge, single user potential, and need to be docked/located. Wireless modalities can improve upon the flexibility and accessibility of information technologies in the healthcare environment, but their lack of dependability and inability to present large format information requires that they remain coupled with a ‘wired’ infrastructure (Gilfor, 01).
Dissolving the disconnect between architectural environments and information technology can be achieved by devising building elements and treatment protocols which would fuse both entities together during the design process, culminating with the creation of a more holistic, digitally integrated setting in which care can be delivered more effectively.
IMPROVED FLEXIBILITY AND ACCESSIBILITY

INTERACTIVE WALL SURFACE

DOMUS ACADEMY, ITALY

MULTI-USER PLATFORM

VARIABLE POSITION COMPUTING

MULTIPLE ACCESS POINTS

Liberating caregivers of fixed position, single user computing stations and replacing them with environmentally integrated, pervasive wall interface elements would alleviate the performance and adaptation concerns associated with those systems. Essentially, any applicable surface within the healthcare environment could become a digital gateway to the information pipeline, improving performance by enabling caregivers the ability to input, access, and transmit data under a multitude of conditions, in a wide variety of locations. Furthermore, integrating these technologies into one seamless wall surface reduces the number of objects with intricate faces and seams that can collect dirt and infectious agents.
However, if digital connections have the potential to exist everywhere, then how does one begin to regulate and define individualized responses for potential users? This issue is especially critical in a healthcare environment, where HIPPA regulations and patient privacy issues abound. Through the use of developing recognition technologies, such as radio-frequency identification devices (RFID), biometrics, and imbedded sensory systems, a level of comfort, control, privacy, and customization over pervasive digital elements can be achieved.
Although the primary purpose of medical technology is to combat illness, its inclusion into primary patient care areas can degrade the level of comfort and control for patients by overwhelming their environment with technological clutter, causing them unnecessary stress. The fusion of architectural elements with technological platforms, as demonstrated by the 'Z. Island Kitchen', can remedy this issue by simplifying, streamlining, and improving their collective ability to improve patient outcomes (Ozler, 01). Liberating the physical environment from the ramifications of technological clutter can also improve the delivery of care by expanding available work areas for staff and increase its ability to be sanitized effectively, minimizing the transmission of infectious agents.
Humane connections to technology can be achieved by generating a sense of comfort and control for the users of the system, including patients, family members, and staff. Interactive elements can also be used to distribute information in the form of colored patterns and shapes to the community and inhabitants of the healthcare facility. For example, lighting combinations in the ‘Touch’ installation could be organized to spell out a message, or shift to a different color to inform users of internal conditions in the facility.
The emergency care environment is a suitable healthcare typology for the architectural integration of information technology due to its dependence on the rapid utilization of data, extensive range of care administered, large range of technological systems employed, high patient turn around rates, and unpredictable volumetric shifts. Contemporary emergency departments are in a state of crisis, plagued by several serious problems including overcrowding, staffing issues, and inability to accommodate surge events (American Hospital Association, 2-23).
The National Emergency Care Crisis

Overcrowding Epidemic
Increase in Utilization Rates

Emergency Care Environment

Staffing Shortages
Declining Number of Available Facilities

Increasing daily and peak utilization rates combined with chronic staffing shortages have spelled disaster for EDs across the United States. Recruiting, retaining and scheduling adequate clinical staff is becoming a severe national problem throughout healthcare, and staffing shortages can be especially problematic in emergency medicine. Emergency departments already overburdened on a regular basis also present a fundamental inability to expand services to accommodate volumetric surges caused by mass casualty events [Lott, 01].
The attacks on September 11th and widespread destruction of Hurricane Katrina have painfully illustrated the overall lack of preparedness that healthcare providers have accommodating for surge conditions in the wake of natural and manmade disasters (Quigley, 01). The operational efficiency of emergency departments during these events becomes critical because they represent the first point of admission to healthcare services for vast quantities of people. Difficulties for emergency care providers to deliver care during mass casualty events stem from insufficient resources and an inability to expand their capabilities to accommodate volumetric surges in order to keep their facilities operational.
In order to ascertain where the integration of information technologies could improve the throughput process of an emergency care facility, it is imperative to understand the basic structure of that system. An analysis of the basic admissions and treatment process highlights critical focus areas within the emergency care environment that would benefit most from the integration of information technology, including the entry triage area, patient exam room, and staff work core.
To ensure the final design holistically satisfies the goal of improving the quality and effectiveness of emergency care through the environmental integration of information technology, a series of design principles were developed from the preceding research. In order to optimize data flow, access to input areas needs to be maximized by conceiving the building as an interface, providing inhabitants with a pervasive, environmentally integrated digital platform in which to utilize information. In order for these environmentally integrated interfaces to respond in a safe and appropriate manner (which is critical in healthcare due to the sensitive nature of the information), then they need to be able to identify and distinguish between potential users (such as nurse, patient, doctor, etc) via utilization of identification technology. The architectural setting can compliment these technologies by blending them into physical threshold conditions, creating digital doorway scanners which identify, track, and monitor the various users throughout the environment. An additional consideration aimed at improving the safety, privacy, and functionality in sensitive environments, the facility needs to be organized into zones of penetration, regulating access to only those users who meet proper security clearances. Furthermore, the facility needs to become like a sponge, expanding and contracting these layers of penetration in an effort to accommodate volumetric increases during mass casualty events. In addition to increasing its capacity, the facility should be prepared to appropriate adjacent existing infrastructure for overflow shelter and staging operations during such events as well.

Using these principles as the basis for the architectural design of an emergency care facility will improve its ability to perform at an optimal level, adapt to changing conditions, and retain a degree of comfort, control and safety for its occupants.
DESIGN PRINCIPLES

BUILDING AS INTERFACE

PHYSICAL THRESHOLD AS DIGITAL SCANNER

LAYERS OF PENETRATION

BUILDING AS SPONGE

APPROPRIATE INFRASTRUCTURE
Access to information can be expanded by conceiving the building as an interface to the community and its inhabitants, where spatial boundaries are reborn as digital connections. Traditionally, architecture has always served as an interface to humans by becoming the surface, place, or point where two things touch each other or meet. This term has also been adopted by the computing industry to represent a common boundary shared by two devices, or by a person and a device, across which information flows (such as the computer screen you may be reading this on right now). This principle is suggesting an amalgamation of both conditions, in which physical surfaces (such as walls) can be fused with digital interface technologies (like computer screens).
Due to their size, large scale exterior architectural interfaces can make daily digital connections to the community, providing a medium to transmit information such as educational resources, advertising, weather advisories, and interactive entertainment. Integration of interface technology into interior architectural surfaces in the healthcare environment can create pervasive computing modalities, improving the efficiency and efficacy of care by providing a universal digital platform to input, access, and transmit medical information rapidly.
It is common to see digital identification systems employed in retail areas near exits to increase security, with electronic tags on store items alerting staff of a potential theft by triggering alarms when a set proximity has been breached. In most cases, store owners prefer that these technologies remain visible to deter malicious actions. In the healthcare setting, visible monitoring technologies can increase visitor and patient anxiety levels, in addition to contributing to spatial clutter in those environments. Providing the level of security and control these technologies afford without the environmental ramifications they cause can be achieved by integrating them into architectural thresholds (such as entry vestibules, patient room entrances, and vertical circulation access points).
While the integration of identification technologies in most examples are purely for security and control reasons, ‘ADA _ The Intelligent Room’ illustrates how they could be used in a comforting, playfully interactive manner to improve the quality of the healing environment (Gullivant, 87). For example, when a family crosses through a threshold condition leading to a waiting space, it could trigger the system to provide them with an interactive floor game, creating a positive distraction while they wait.
The three main categorizations of people who exist within the emergency care environment include public, patient, and staff typologies. In order to further improve security, the facility needs to be designed into layers of penetration, regulating access to only those groups who meet proper security clearances in order to maintain safety, maximize operational effectiveness, and ensure a level of privacy and control in sensitive environments. This organizational model, coupled with the added security of physical threshold scanners, can create an optimum level of safety and control, which is a critical factor if the facility is to be utilized by large quantities of people during mass casualty events and remain operational.
Regulating visitor penetration into sensitive environments, such as the staff work core, would provide several improvements including a decrease in the level of contamination from outside sources in the event of a biological, radioactive or chemical event, as well as minimization of staff distractions and crowding from visitors in work areas. This principle is directly related to overall organizational layout of facility, and should be considered in the primary stages of the design process.
In anticipation of volumetric surge conditions during mass casualty events (such as hurricanes, earthquakes and terrorist attacks), the organizational layers of penetration need to be expandable, ensuring that the facility will be able to accommodate rapid, unpredictable, and significant increases in utilization when it is needed most. The building and its infrastructure need to act like a sponge, expanding and contracting the layers of penetration so that it can be reorganized and reconfigured in order to accommodate sharp increases in patient volume. The measure of expandability for a facility lies in its effective reuse of non-critical spaces and adaptation of existing spaces.
In the ER One Project, the concept of ‘scalability’ drove the design of several key areas within the facility, including non-essential spaces, patient examination rooms, and exterior facade considerations. Additional bed capacity was gained by adapting non-essential spaces of opportunity such as hallways, auditoriums, atriums, conference rooms, administrative space, and waiting areas. Adjacency of primary resources, use of a sanitizable materials, and collocation with ancillary support services such as restrooms was designed into these spaces.
Availability of sheltered and/or open spaces adjacent to the facility plays an important role in its ability to expand effectively. In addition to increased capacity, the facility should be collocated with adjacent, existing infrastructure elements such as bridge overpasses, structured parking garages, fresh water supplies, and established green spaces, all of which can be appropriated for usage during mass casualty events. Planners must ensure that potential adjacent staging areas are established (unlike vacant lots, and abandoned buildings), and will remain available for utilization in the foreseeable future.
Appropriated infrastructure (bridge overpasses, established green spaces, parking garages, etc.) can be utilized for the many uses during surge events including space for initial screening and triage, decontamination, overflow shelters for the homeless, open areas to conduct staging operations by disaster relief agencies such as FEMA and the Red Cross, access to clean water reserves to ensure sterility during the decontamination process, and storage space for stockpiling and dispensing of supplies, food, and water.
Typically, emergency departments are attached to larger, comprehensive healthcare facilities, acting as the primary point of entry for approximately half of all admittances into hospital inpatient facilities. However, this type of emergency department design or renovation introduces an abundance of non-pertinent issues into the project proposal, including phasing considerations and adherence to existing layouts. The selection of a freestanding emergency care facility eliminates these concerns related to the thesis study, while adding the benefits of increased provider coverage areas and expansion of system capability to prepare for and accommodate surge volumes from mass casualty events.
Although they remain a rarity in the US, freestanding emergency care facilities offer several benefits to healthcare providers that are not available if all services are concentrated into one, comprehensive facility. Improvements upon existing regional healthcare infrastructure include expanding provider coverage areas, minimizing travel distances to available facilities, increasing the ability to effectively deliver care, relieving volumetric burdens on existing centralized facilities, and increasing effectiveness during mass casualty events.
The program is based off a similar model used for Callison Architect’s Swedish Medical Freestanding Emergency Department in Seattle, Washington, and consists of an emergency care department with an adjacent imaging and outpatient care center. The program was modified to include provisions for mass casualty surge events in which the occupancy for the facility would increase dramatically. Several spaces, such as the waiting area and patient examination room, were designed to be scalable in order to be modified and adapted during mass casualty surge events.
A series of potential mass casualty event scenarios were developed in order to effectively prepare simulations to test possible responses from the facility's program. The scenarios were based on a similar set of conditions put together for the ER One “All Risks Ready” Emergency Care Center in Washington DC. Each scenario consists of an operational level (defined by a color), expected patient loads per hour, anticipated events, and the facility's response.
The city of Charleston, South Carolina was selected as the area to implement the thesis proposal due to its proximity to Clemson, SC, rapidly expanding population, regional demand, and susceptibility to mass casualty events. The Charleston Region is vulnerable to several natural disasters including hurricanes, floods, and earthquakes, as well as a potential target for terrorist activities due to its population concentration and international air and seaport connections. Determination of the site’s location within the selected region was driven by its ability to effectively accommodate the purposed facilities programmatic needs during daily operations, as well as prepare it for mass casualty events.
Charleston’s recent population increase, coupled with the upgrade and replacement of significant elements of its regional highway infrastructure, has expanded growth north into previously underdeveloped areas on the periphery of the city. In addition, the demand for an increase in regional surge emergency treatment capacity, significant problems with existing healthcare infrastructure in the city of Charleston raise concerns as to their level of preparedness. Healthcare services are concentrated on the western side of the peninsula, where three independent hospital systems (MUSC, Bon Secours Roper St Francis, and VA Veterans) coexist within a large campus. The concentration of services is sited in a lower level of the flood plain which only provides 3 – 6 ft of elevation.
The construction of the Arthur Ravenel Jr. Bridge in 2005 marked the opening up of a significant portion of land in the greater peninsula of Charleston. With support from Mayor Riley, an initiative was launched by Charleston Civic Design Center to redevelop the area which had once been home to the Cooper River Bridge in the form of a mixed-use residential development. The main goal of the development is to recapture areas once considered on the fringe of Charleston, and re-stitch the urban fabric that was disrupted by the original highway overpass and bridge approach. The lack of significant historical context in this area also affords a level of freedom to future developments, as sensitivity to surrounding structures is minimized due to their level of dilapidation and zoning.
The site also provides a high level of accessibility due to its location adjacent to major primary regional arterials I-26 and I-17, as well as the primary urban roads Meeting Street (NS connector) and Huger Street (EW connector). Additionally, the land shields and enables the facility to operate effectively during mass casualty events for several reasons. The property consists of high, stable land which can limit damage from flooding and earthquakes. Since the site is not an infill site, as is the case with many areas on the peninsula, the land affords a higher level of seismic stability for the facility than much of the peninsula. Adjacency to civic infrastructure and open land will enable the facility to expand beyond its site to accommodate disaster relief staging activities.
The organization of the site and adjustments to surrounding infrastructure centered around optimizing visibility and accessibility to the facility for patients, visitors, staff, services, and incoming disaster relief agencies. A rapid access ramp was added to the I-17 overpass to enable service vehicles heading into Charleston on I-26 (such as ambulances and supply trucks) to exit directly adjacent to the site, rather than further south where I-26 terminates onto Meeting Street. A transitional condition between the highway overpass and surrounding neighborhood was utilized as an organizational tool for the hierarchical arrangement and definition of key exterior digital interface elements.
Due to its elevation and visibility from the downtown peninsula up the Meeting St corridor, the I-17 highway overpass was a suitable platform to appropriate for the integration of a digital, urban interface in which to distribute information in the form of advertising, media, and alerts. The appropriation of the highway overpass infrastructure was taken a step further, creating a life support structure underneath that would provide the facility with vital functions (shelter, water, and power generation) during disaster events, as well as sustainable design features during daily and emergency operations.
The location and scale of the integrated façade at the corner of Meeting and Huger St. was aimed at reinforcing its visibility and effectiveness at disseminating information (through use of color and patterns) to the community. The corner placement enables the facility to be visible down both vehicular corridors, most notably Meeting Street which extends into the heart of the city. Visibility was a major driver for the design of the digital elements, as the primary role of the integrated façade interface was to display the facility’s activity level.
Due to its elevation and visibility from the downtown peninsula up the Meeting St corridor, the I-17 highway overpass was a suitable platform to appropriate for the integration of a digital, urban interface in which to distribute information in the form of advertising, media, and alerts. The appropriation of the highway overpass infrastructure was taken a step further, creating a life support structure underneath that would provide the facility with vital functions (shelter, water, and power generation) during disaster events, as well as sustainable design features during daily and emergency operations.
The location and scale of the integrated façade at the corner of Meeting and Huger St. was aimed at reinforcing its visibility and effectiveness at disseminating information [through use of color and patterns] to the community. The corner placement enables the facility to be visible down both vehicular corridors, most notably Meeting Street which extends into the heart of the city. Visibility was a major driver for the design of the digital elements, as the primary role of the integrated facade interface was to display the facility’s activity level.
The building was organized into layers of penetration, with public and service functions subdividing the ground level into distinctive zones. The service areas were located adjacent to the bridge overpass for accessibility, and include a supply loading area, EMT and police substation, and ambulance parking area. Programmatic public elements on the ground level include a community center, delicatessen, and parking areas.
The community center serves as a flexible area which can be adapted to meet the current neighborhood needs (soup kitchen, homeless shelter, clinic, etc.). A digital community wall element was integrated into the exterior façade of the community center to enable public accessibility to medical and educational data.
Critical medical care areas were elevated in order to control access to the facility as well as protect it from a potential 20 foot flood surge. The floor was split between imaging services (east) and emergency care area (west), both of which are accessed through a central entry point via the airport-like drop-off ramp. The building was organized into layers of penetration, with patient and visitor circulation being placed along the exterior of the building, and staff areas at its core.
The layout of the emergency department was organized into an acuity loop, with fast track services located in a location closer to the entrance/exit, and higher acuity areas (trauma, observation) adjacent to the ambulance and staff entry on the northern side of the facility.
The structural logic for the facility was split into two distinct elements, a slab platform supported by concrete columns for the first [elevated] floor level, surrounded by an enveloping steel truss/column system anchoring a shed roof. This enables a level of flexibility on the main patient care level for future reorganization of programmatic elements by minimizing the number of existing columns. Roof trusses adjust in profile, shift in orientation and weave down the length of the facility, with each change indicating a programmatic intersection below.
The trusses extend over the front concourse drop-off area to provide shelter from the sun and rain for people during entry to the building. All columns were designed to include base-isolators, ensuring their stability and safety under dynamic loading conditions [earthquakes or hurricanes].
ENTRY RECEPTION AND TRIAGE

The entrance to the facility is defined by two digital revolving doors which open into the central triage area. These doors serve as thresholds for the primary scanning and identification of all incoming people. Digital kiosk elements integrated into the reception desk greet people as they enter the facility, and enable rapid check-in to the facility through input of basic information (name, reason for visit, scan of ID). The receptionist then tags each person with an RFID bracelet and directs them according to their needs (patient, imaging outpatient, or visitor).
Clustered waiting components are organized along the exterior of the facility in order to minimize crowding and increase the level of comfort and control for inhabitants. A visitor data wall element is provided for waiting persons, enabling access to different forms of media including educational data or internet access.
At the center of the staff and visitor circulation paths lies the standardized patient examination space. The space is organized into a series of zones, including sanitation, clean, patient, and visitor. All of the rooms in the unit are universally organized into same-handed environments, further standardizing the space for efficient and effective patient care. The patient area is outfitted with a mobile bed and a digital headwall. The digital headwall consists of a touch screen display with patient vitals and monitoring functions.
The footwall is a multi-touch sensory surface which enables staff to present large format images and access digital resources. Patients and families can use it as a media platform for educational and entertainment purposed when staff are not present.
The overall footprint of the staff work core was minimized by integrating systems into wall and work counter surfaces, the creation of a vertical supply delivery system integrated into the work station, and location of administrative and staff respite areas out of the core. By minimizing the work core footprint, efficiency can be optimized by reducing the number of total steps required by staff. Staff respite areas were elevated to a mezzanine level, enabling the overall footprint of the unit to remain minimal without compromising accessibility to those spaces.
Additionally, the mezzanine level opens up the staff core spatially, allowing natural light to penetrate the space through a series of clearstory windows. Elevated digital vital signs displays enable staff to visualize the status of their patient at any point within the unit (including the mezzanine).
During mass casualty events such as hurricanes, earthquakes and terrorist attacks, the facility is designed to accommodate volumetric surges of patients and distressed persons. The building acts like a sponge, expanding itself through adaptation of non-critical interior spaces, utilization of its architecturally integrated digital elements, and expansion of its services to surrounding areas. The entrance area is able to accommodate for surge capacities by expanding its services beyond the doors of the facility and onto the concourse entry area.
Patients are prescreened externally at control points along the base of the drop-off area to add an additional layer to the filtration process, only admitting those patients who truly need medical attention. Once inside and scanned, the reception kiosk has been ever designed in order to accommodate increased activity.
The waiting areas are designed into a series of modules which can be activated as different levels of occupancy are reached. As they are activated, staff moves existing furniture to clutter corners located at the ends of each space. Deployment of privacy screens imbedded into the structural splints defines each surge patient care area, with a digital interface integrated into its surface to enable connections to virtual doctors for rapid staff increase. Surge gurneys were placed in the base of the curtain wall for rapid deployment.
Mobile supply carts can be quickly deployed from the staff core and nested along the circulation corridor. The family data portal can be used by staff to act as a second decentralized nursing station, which coupled with wireless PDA systems enables rapid information utilization.
INCREASED STAFF ACTIVITY

The pervasive digital workstations enable multiple caregivers to access information simultaneously, a marked improvement over currently implemented single user platforms which have fixed positions and limit overall usage. Decentralized wall portals add another layer of potential platforms for staff to utilize information, therefore minimizing the potential for backups and waiting for computing modalities to become available. A second series of patient vitals are activated below the daily display, monitoring those patients who are in surge modules.
The clean supply area within the patient exam space can be compressed into the wall in order to accommodate an additional surge gurney, doubling the occupancy of the room. The digital headwall is designed to include two sets of hookups, as well as digital resources to display each separate patients' vitals.
Relief agencies such as FEMA and the Red Cross can mobilize their forces in the centralized command center element in the Life Support Structure. Around this central base camp, services such as FEMA trailers, supply distribution, and storage can be expanded to sheltered areas underneath the bridge overpass. Also, connections to fresh water supplies (via the digital water tower) were provided in this area. Power resources are never severed to the facility due to the solar shelter and a series of generators elements located in the Life Support Structure. If required, decontamination activities can occur on the ground level of the care facility through appropriation of the public parking area.
Each respective church in the immediate vicinity of the facility will become a hub for a specific relief function, with shelter occurring to the west, distribution areas occurring to the south, and storage functions occurring to the east. Altogether, the facility is at the center of a comprehensive point of distribution site for healthcare, shelter, supplies, and resources, providing these vital services all within range of one another in order to properly care for and distribute the various populations of people who will descend on the building during disasters.
CONCLUSIONS

The digital interface elements integrated into the building also adapt to accommodate the surge conditions. The exterior façade shifts to a deep red, drawing attention to the facility as well as informing urbanites that it remains operational and can accommodate their needs. The community and bus stop display elements transform to provide remote, digital connections to those within the facility. This enables family members to be present with those inside receiving care, without infiltrating the space. These displays can be further utilized to include missing person reports and recent fatalities, increasing awareness and knowledge during chaotic conditions.

By integrating digital technologies into the environment, architecture can serve humans in a revolutionary new way. The architectural design of healthcare environments needs to be a collaborative process across disciplines and industries, rather than the isolated, reactionary state in which it exists today. The power of this integration lies in its ability to improve the delivery of care by maximizing accessibility to information, enabling more flexible environments and systems, and remediation of the healing environment through its liberation of technological clutter. While the benefits of this marriage were displayed in the emergency care environment, it is important to note that they could transfer to any area within healthcare, or the greater field of architecture for that matter. It is when technology is truly merged with the physical environment that its true potential can be unleashed.


Refer to the thesis manuscript for a comprehensive overview of the research and complete bibliography.