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The Interactive Medical Emergency Department (iMED): Architectural Integration of Digital Systems into the Emergency Care Environment

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THE INTERACTIVE MEDICAL EMERGENCY DEPARTMENT [iMED]:
ARCHITECTURAL INTEGRATION OF DIGITAL SYSTEMS INTO THE EMERGENCY CARE ENVIRONMENT

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

David Benjamin Ruthven

May 2007

ABSTRACT

In healthcare, the architectural response to the development of information technologies has largely been relegated to a reactive role, essentially waiting for systems to develop 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. The flexibility of the environment is compromised by fixed position, single user data systems which prevent it from actively adapting to changing conditions, especially during volumetric surges associated with mass casualty events. Additionally, the delivery of care is hindered by traditional data entry points which minimize the caregiver's ability to utilize information effectively by increasing distances to, and wait times for, available platforms. Furthermore, the overall quality of the healing environment is degraded by the increasing amount of technological clutter which can be difficult to sanitize, intimidating to patients, and unsafe by frustrating care.

Dissolving the disconnect between architectural environments and information technology 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. Utilizing advances such as integrated wall interfaces and environmental sensor systems would improve the delivery of care by empowering users and architectural settings with the ability to effectively adapt to changing conditions, increase accessibility to information, and streamline care for improved patient outcomes. Replacing fixed position, single user data entry systems with environmentally integrated surface interfaces would improve flexibility and performance by creating a multitude of localized points to access data, as well as streamline and simplify the environment by eliminating technological clutter.

The process in which to derive an architectural response to the thesis statement was initiated by performing a series of interviews with nationally prominent professionals in the fields of healthcare architecture and information technology, attending international design conferences, interning in health facilities, assembling a cross-disciplinary thesis committee, and conducting a thorough literature review. The thesis

research phase began by studying the historical progression and significance of information technology in healthcare environments in order to discern the architectural role in the implementation of these systems. The research focus was then shifted to all areas of architecture, identifying applicable precedent studies in which the environmental integration of information technology had enhanced the quality of the setting, highlighting characteristics that would improve flexibility, performance, and outcomes in the field of healthcare. From this exploration, a series of typological selection criteria were developed in order to determine which area within the healthcare spectrum would best demonstrate the potentials of this union. 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, fast paced care delivery which is dependent on the rapid utilization of information, and high patient turnover rate requiring an efficient throughput processes. Specific problems relevant to contemporary emergency departments were then identified, including overcrowding, staffing issues, and inability to accommodate for volumetric surges, all of which stem from inadequate throughput methodologies. The thesis then explored how the fusion

of digital modalities with architectural elements in the emergency care environment would remediate these problems by improving the 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. In order to optimize data flow, access to input areas must be maximized by conceiving the building as an interface, where spatial boundaries become digital connections. If integrated data systems are to be accessible from a universal architectural interface and respond in a safe and controlled manner, digital scanning technologies such as biometrics and RFID tagging must be fused with physical threshold conditions in order to enable the digital system's recognition of its inhabitants. In an additional effort to maintain safety, maximize workability, and ensure a level of sterility in sensitive environments, the facility needs to be designed into layers of penetration, regulating access to only those users who meet proper security clearances. Furthermore, the facility needs to act like a sponge, easily expanding and contracting the layers of penetration in an effort to accommodate unpredictable volumetric increases during

mass casualty events. In addition to increasing its capacity, the facility should also be prepared to appropriate adjacent, existing infrastructure for overflow shelter and staging operations during such events.

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. Although rare in the US, freestanding emergency care facilities are a viable option for expanding healthcare provider's coverage, capturing areas with growing populations, and improving the regional capability to respond effectively during mass casualty events. The base program was derived from the Swedish Medical Issaquah Campus Freestanding Emergency Department in Seattle, Washington, and then modified to function as a Point of Distribution (POD) site during mass casualty events. A series of potential mass casualty event scenarios were then developed in order to effectively prepare conceptual simulations to test possible responses from the facility's program.

The thesis proposal consists of a freestanding, 40,000+ square foot Interactive Medical Emergency Department (iMED) located in Charleston, SC. The proposal is guided by an 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. In order to provide a range of possible disaster response situations, the building was located in the densely populated peninsula area of Charleston, South Carolina, within a region which is susceptible to an assortment of mass casualty events (including hurricanes, earthquakes, and terrorist attacks). The final site within the urban context adheres to a set of established criteria, including placement on open, stable, elevated land adjacent to the major access arterials of I-26, Hwy 17, and Meeting Street. Additionally, the site was located within a rapidly expanding, non-historical sector of the city which is not part of an existing healthcare complex. By meeting regional and urban conditions defined in the criteria, the site's location strengthens the facility's ability to deliver care during both daily and surge conditions substantially.

DEDICATION

This thesis is dedicated to my wife Lauren and family.

ACKNOWLEDGEMENTS

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

To the American Institute of Architects Academy of Architecture for Health for granting me the 2006 - 2007 Arthur N. Tuttle Jr. Graduate Fellowship in Health Facility Planning and Design to conduct this thesis project.

To my thesis committee for their dedication, encouragement, and guidance.

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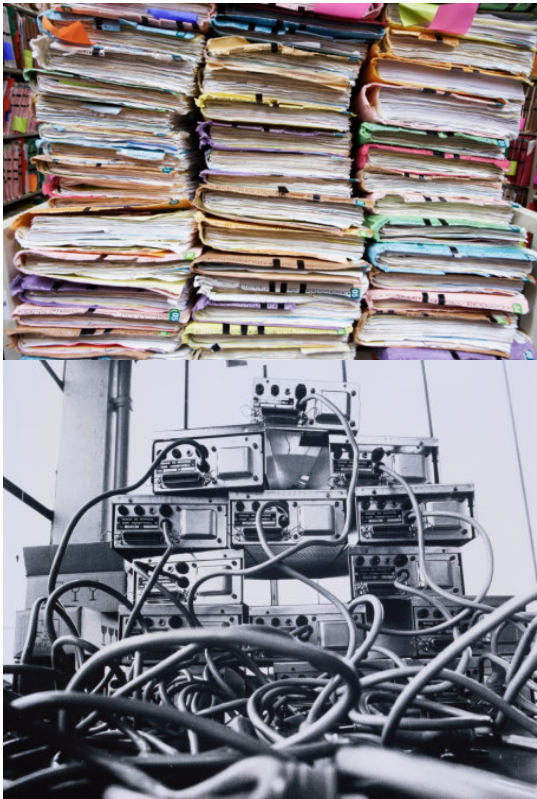
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THE DIGITALLY INTEGRATED CARE ENVIRONMENT



01. Different Systems, Similar Problems
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During the early 20th Century, the inception of the patient medical record signified the recognition that the ability to capture, organize, and access information in the healthcare environment was a crucial component in the effective delivery of care. Since then, accessibility to this informational lifeline has been a critical consideration in the design of modern healthcare architecture. A methodological paradigm shift in data collection occurred during the last quarter of the century as a result of personal computing modalities and advances in telecommunications (collectively called information technologies), causing dramatic shifts in the quantity, accessibility, and transmission of data within caregiving environments. However, healthcare architecture today remains disconnected from these systems, merely reacting to them with appropriately sized spaces. This disconnect degrades the delivery of care by creating a lack of flexibility, decelerating performance, and disrupting the healing environment. The flexibility of the environment is compromised by fixed position, single user data systems which prevent it from actively adapting to changing conditions, especially during volumetric surges associated with mass casualty events. Additionally,

the delivery of care is hindered by traditional data entry points which minimize the caregiver's ability to utilize information effectively by increasing distances to and wait times for available platforms. Furthermore, the overall quality of the healing environment is degraded by the increasing amount of IT clutter which can be difficult to sanitize, intimidating and stressful for patients, and unsafe. Just as the paper based system evolved to personal computing, it is time for the next logical step in the evolutionary process towards a digitally integrated environment to begin.



02. Next Evolution: Digital Architecture

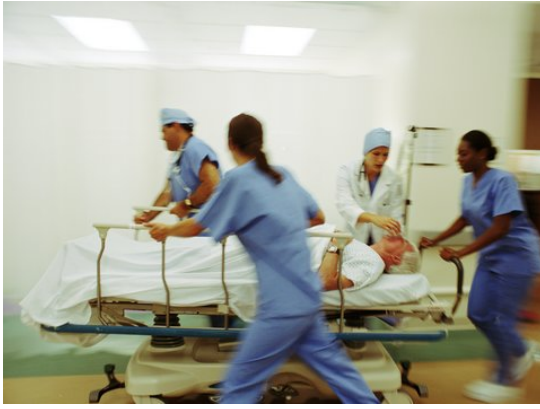
2007 // Ruthven



03. Digital Wall Interface: Minority Report
2002 // 20th Century Fox

In the 21st Century, buildings are becoming more than just shelter through the fusion of digital elements, reaching new connections with their inhabitants from the integration of sensory response systems and environmental interfaces. Recent architectural examples of IT integration in various areas of the industry (ranging from stadium to residential precedents) are improving upon their ability to adapt to changing conditions, provide accessibility to data outlets, and streamline the environment by integrating these systems into the framework of their design. Many of these intriguing technologies can transfer over into the healthcare environment. For example, innovations such as the digitally integrated wall interface can be employed by the healthcare sector to remedy accessibility, flexibility, and spatial constraint problems associated with the current disconnect between the environment and IT systems. Bridging the gap between architecture and technological systems can create a more holistic, digitally integrated environment in which to effectively deliver healthcare by enhancing its capability to adapt to changing conditions, improve operational performance, and provide a technologically sophisticated healing environment.

The emergency care environment is an appropriate healthcare vessel in which to test the capabilities of digitally integrated architectural due to its unpredictable volumetric



04. The Fast Paced Emergency Care Environment

2007 // Getty Images

shifts which require flexible environments and systems, fast paced care delivery, dependence on the swift utilization of information, large quantity of technological systems, and high patient turnover rates which require quick turnaround of spaces. Contemporary emergency departments in the United States are in a crisis, overwhelmed by overcrowding, staffing issues, and the inability to expand during surge events. These problems can be traced in part back to inadequate throughput methodologies which stem from inflexible, antiquated facilities infiltrated with obsolete IT systems. An analysis of the basic throughput process highlights three critical focus areas within the emergency care environment that would benefit most from the architectural integration of digital technology, including the entry triage area, patient exam room, and staff work core. These three focus areas all incorporate information technologies in different ways, but share a commonality in that they do little to integrate those technologies into the framework of the environment. Therefore, a critical component in the overall investigation was to test the potentials of digital integration in those areas in an effort to remedy the inadequate throughput methodologies which have stymied emergency departments across the nation.



05. The Foundation for Design
2007 // Getty Images

Acting as a conduit between the research phase and proposal phase of the project, a set of design principles were derived to ensure that environmental integration of information technology would improve the quality and effectiveness of the emergency care setting. Conceiving the building as an interface, where spatial boundaries are reborn as digital connections, can maximize the flow of information by improving accessibility and visibility of technological systems. Safety, privacy, and control for different users (staff, visitor, patient, etc) who access environmental interface systems can be obtained by designing physical thresholds as digital scanning portals via utilization of identification technology. Another way in which to maintain safety and privacy, maximize workability, and ensure a level of sterility in sensitive environments, is to design the facility into layers of penetration, regulating access to only those users who meet proper security clearances. Increasing the flexibility in each layer can be achieved if the facility acts like a sponge, expanding as needed in order to accommodate volumetric increases during mass casualty events. Recognizing that a single facility cannot provide adequate services to massive surge crowds, the building should be prepared to appropriate adjacent existing infrastructure for overflow shelter and staging operations during such events. Using these principles as the basis for the architectural design of an emergency care facility can improve its ability to perform at



06. Pure Condition: Freestanding
Emergency Departments
2007 // Getty Images

an optimal level, adapt to changing conditions, and retain a degree of comfort, control and safety for its occupants.

With the intention of eliminating extraneous influences from distracting from the research and design focus, the programmatic typology of a freestanding medical emergency department was selected. In addition to not being limited by the constraints of an addition and/or renovation project, freestanding emergency care facilities are a viable option for expanding healthcare provider's coverage, capturing areas with developing populations, and improving their network's capacity to respond effectively during mass casualty events. A series of potential mass casualty event scenarios, based on similar models used to design the ER One 'All Risks Ready' hospital in Washington DC, were then developed in order to ascertain bed counts used to effectively determine the facility's program during daily and surge operations. The base program was derived from the Swedish Medical Issaquah Campus Freestanding Emergency Department in Seattle, Washington, and then modified to function as a Point of Distribution (POD) surge facility which can deliver care to increased patient



07. The Power of Nature
2007 // Getty Images



08. The Power of Man
2007 // Getty Images

levels as well as provide staging areas for disaster relief agencies during mass casualty events.

The city of Charleston, South Carolina was selected as the area to implement the thesis proposal due to its proximity to Clemson University (the place of study) and Charleston's rapidly expanding population. The Charleston region was also appropriate due to its susceptibility to mass casualty events including naturally occurring hurricanes, floods, and earthquakes, as well as the potential to be a site for manmade terrorist activities resulting from 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 shield and prepare it for mass casualty events. The selected project site within the Cooper River Redevelopment neighborhood adhered to an established set of site criteria because it was stable, elevated location adjacent to major arterials and civic infrastructure, and within a rapidly expanding, yet non-historical sector of the city.



09. The Convergence of Disciplines
2007 // Getty Images

The Interactive Medical Emergency Department (iMED) is intended to serve as a catalyst for the integration of information technology into the architectural framework of the healthcare environment. Directed by the established set of design principles, the design of the freestanding, 40,000+ square foot emergency care facility was conducted with the fundamental goal of improving the delivery of emergency care during daily operations and mass casualty surge events through the architectural integration of information technology.

While the proposal is limited to demonstrating the potential benefits of technological integration in a specific setting type, the overall intent of the investigation was to uncover information during the process which could be transferable across disciplines, be it healthcare, architecture, technology, or otherwise. It is the holistic convergence of these disciplines which can elevate architecture, and the humans who inhabit it, to higher levels in the new millennium.

HEALTH AND HEALTHCARE ARCHITECTURE IN THE AGE OF INFORMATION

As a general rule, the most successful man in life is the man who has the best information.

Benjamin Disraeli
British politician (1804 - 1881)



10. Focus on Health
2007 // Ruthven

Beginning with the inception of the patient medical record during the early 20th Century, the need to capture, organize, and access information in the healthcare environment has become a vital component in the effective delivery of care. As a result, the design of modern healthcare architecture has been, and continues to be, heavily influenced by the need for accessibility to this informational lifeline. As the turn of the 21st century approached, personal computing modalities and advances in telecommunications - collectively called information technologies (IT) - created dramatic shifts in the availability, accessibility, and usability of data within caregiving environments. In spite of these rapid technological developments, healthcare architecture largely remains relegated to a reactive role, essentially waiting for technologies to develop and methodically accommodating them within appropriately sized spaces. Simply placing various, isolated IT systems within the healthcare setting without any real connection to their environment inhibits them from reaching their full potential as vital components in the overall delivery of care.

Information and the Delivery of Care



11. Dr. Henry Plummer, Founder of the Paper Based Medical Records System
2007 // mayoclinic.org

An increase in the availability and quality of healthcare providers during the early 20th Century, coupled with growing population rates in the United States, led 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.

The Paper Based System // The healthcare environment's fundamental reorganization around an informational system began when the first effort to organize patient information into a centralized, singular paper medical record was devised and initiated in 1903 by Dr. Henry Plummer of the Mayo Clinic. Each file brought together all of a patient's vital information, including their medical history (previous clinical visits, hospital stays, etc), pre-existing conditions (allergies, chronic illnesses), laboratory



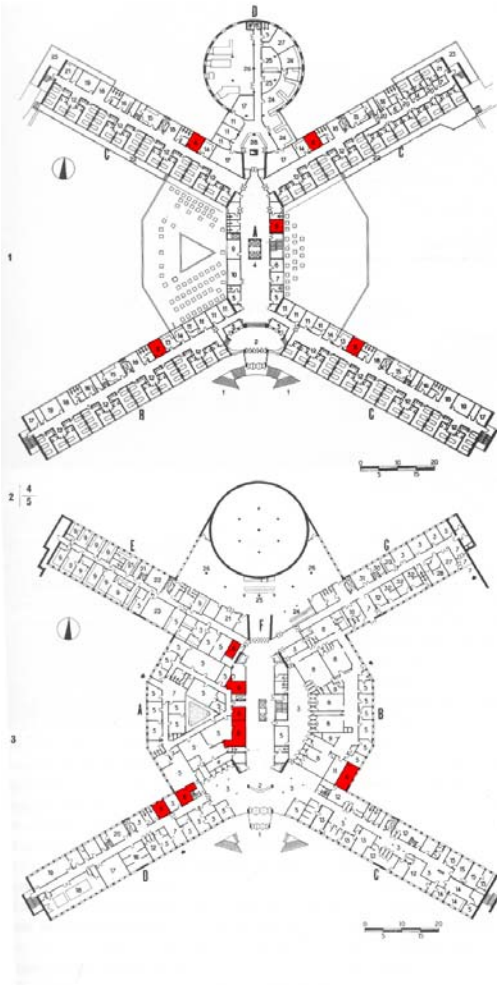
12. 1914 Building by Ellerbe Architects
2007 // mayoclinic.org



13. Pneumatic Tube System
2007 // mayoclinic.org

tests, and practitioner notes into a single record. Each file was coded with an identification number in order to organize and expedite retrieval from a central repository storage area. The 1914 Building, which was constructed around the principles, concepts, and systems of Dr. Plummer, was the first architectural attempt to create an environment supportive of the new paper based information system. The design included expanding nurse stations to include charting and records storage areas, as well as a central repository space for the archiving of patient medical records. Additionally, Dr. Plummer worked with Ellerbe Architects to integrate a system of conveyers and pneumatic tubes, which he had discovered from an investigation into the methods and systems that factories and businesses used to manage information, into the overall design of the facility. This advanced system enabled caregivers to rapidly transport records and correspondence throughout the building within a matter of minutes [Mayo Foundation for Medical Education and Research, 01]. The architectural environment truly began to restructure itself in order to facilitate the recording, movement, and accessibility of information.

The widespread use of patient medical records in the US began to occur after WWII, due to services being expanded by the Hill-Burton Act of 1946 and a rapid increase in



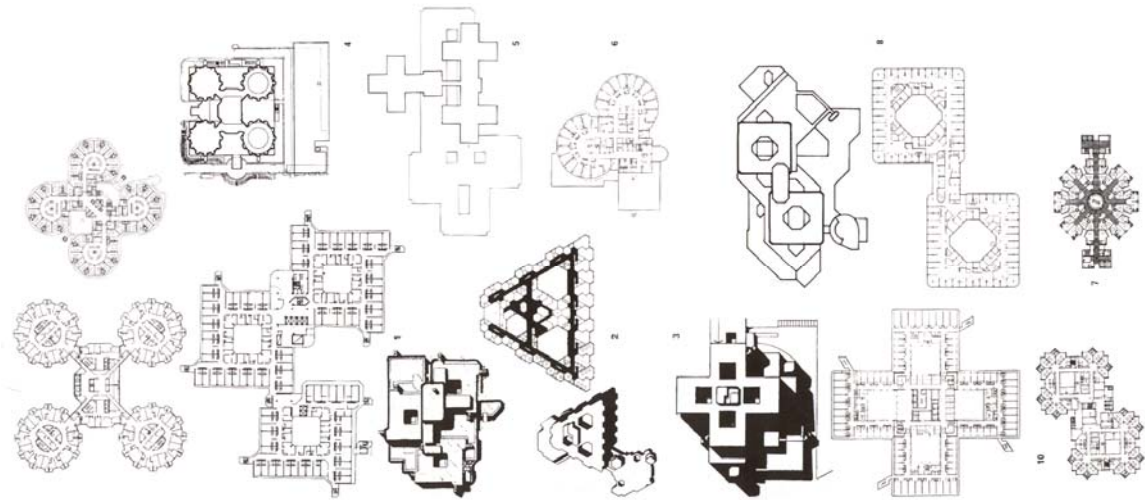
14. Floor Plans of the Gonesse Hospital Center with Dispersed Medical Records Rooms (Red)

2000 // Verderber, Fine

national population known as the 'baby boom' (Hannah, 31). As the use of paper medical records became a standard practice during the second half of the 20th century, the solitary use of a singular, centralized data repository began to dissolve as providers scrambled to find room for and improve accessibility to the thousands of medical files they were amassing. Inpatient units began to be designed with individual, dispersed records storage areas (in addition to a central repository) in order to decrease the time required to travel, locate, and access information. The deconstruction of generalized care areas into specialized departments during this time was also a harbinger of this change, as individual units desired to separate their specific family of records from the rest of the patient records used in other clinical specialty areas within the hospital. The plan for the Gonesse Hospital Center (constructed in 1970) illustrates this shift in design from a singular repository to decentralized, department specific storage areas, with each individual inpatient unit containing its own medical records room [Verderber, 42-48].

However, healthcare providers' desire to compress the overall size of each unit in order to improve efficiency conflicted with the addition of these new programmatic elements, triggering an increase in architectural experimentation with patient care unit

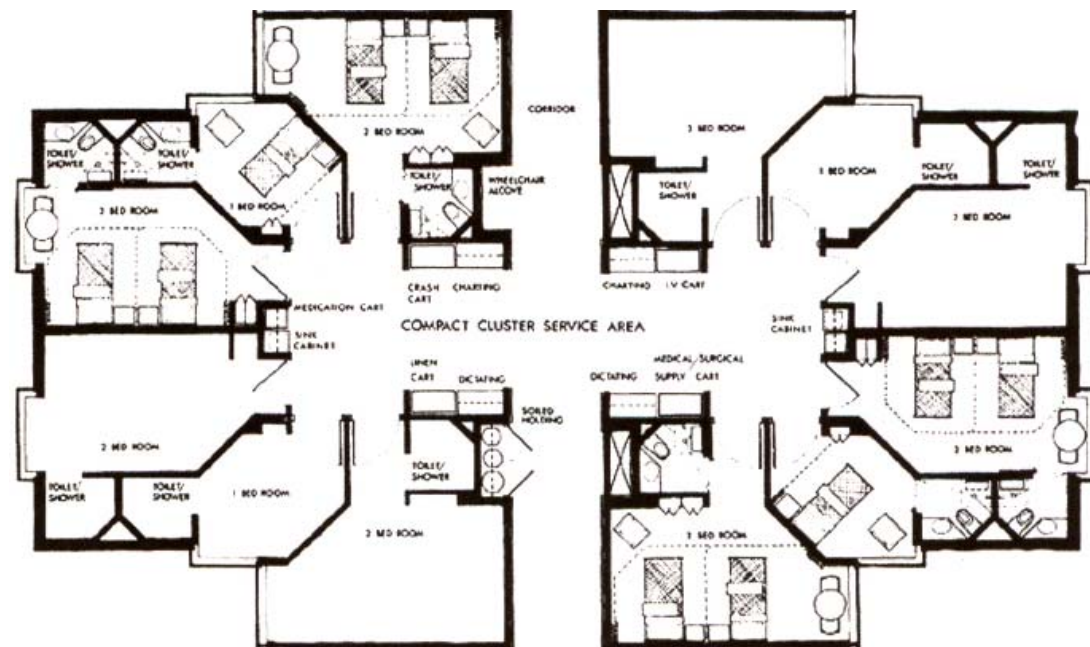
plan and space typologies other than the open ward during this time [Verderber, 72-76]. A new model for nursing unit design emerged to dominate this period, stemming from the desire for efficiency (as documented in the Yale Traffic Index) and endorsed by prominent healthcare architects Normand E. Girard and Herbert Bienstock of Zachery Rosenfield & Partners, NY. The Yale Traffic Index, the first mathematical model of the nature, purposes and frequency of staff movements (which appeared in 1960 and was later refined by Lippert in 1971), was developed to measure the efficiency of these new unit typologies in terms of walking distance (Estryn-Behar, 04). The study concluded that units with compound circulation patterns rated highest on the score, citing racetrack plans as one of the most efficient typologies.



15. Experimental Patient Unit Typologies

2000 // Verderber, Fine

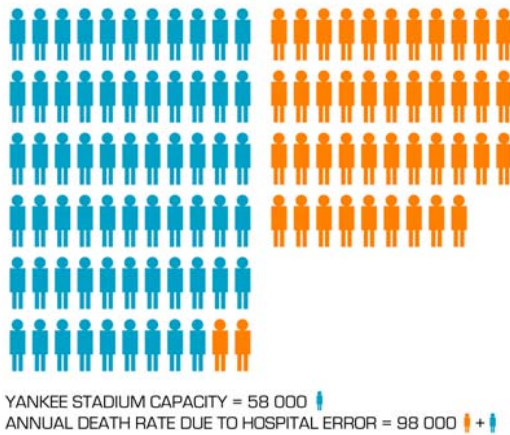
During the 1970's, the clustered unit typology emerged as an efficient model to follow because it brought together and combined key staff support elements (including nurse charting areas) which had been developing in random fashion for the previous 20 years into a series of compact, individual units. Key components to the design were the deconstruction of the central nurse station into individualized charting areas and provisional storage of medical supplies and work areas at the point of care (Verderber, 202-203). This revolutionary unit design was first used at the Somerville Hospital in Massachusetts in 1974 to much initial success.



16. Clustered Nursing Unit Design at Somerville Hospital, Massachusetts
1974 // Verderber, Fine

Further adaptations on the design of nursing units also began to emerge, most notably the 'nurseserver' concept developed by hospital consultant Gordon A. Frieson, which moved care giving materials, including the patient chart, out of centralized support spaces into supply closets at the entry to each patient room (Verderber, 2003). Frieson's unique approach to patient care anticipated, but did not benefit from, advances in information management systems such as material and equipment bar coding and the electronic medical record. Unfortunately, it was ahead of the IT curve and ultimately failed due to breakdowns in information management and communication in the paper based and analogue era.

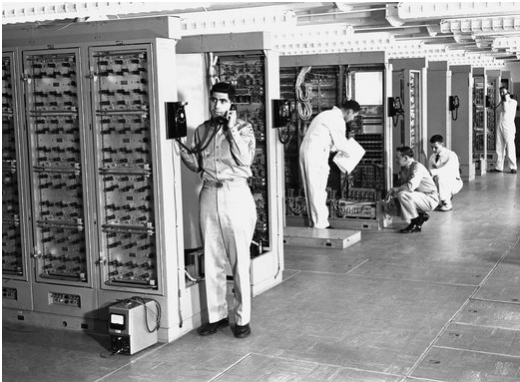
While the widespread emergence of decentralized staffing and charting areas in the late 20th century did increase the operational flexibility of the overall unit for nursing staff, it also began to surface problems with the paper based system itself. Since paper records were being spread out across many different areas and multiple care providers (nurse, doctor, lab tech, nurse assistant, etc) all needed simultaneous access to patient data in various locations, records management issues and breakdowns began to plague the system, ultimately increasing the potential for medical errors.



17. National Medical Error Crisis

2007 // Ruthven

The alarming rate of medical errors was exposed in the seminal work by the Institute of Medicine, “Crossing the Quality Chasm: A New Health System for the 21st Century”, which cited that approximately 98,000 people die annually as a result of preventable medical errors. Paper based medical records systems were indicted as a one of the major contributors to this dire problem, with issues stemming from the lack of uniformity across records, illegible handwriting notations, and lack of communication/file sharing between separate healthcare providers (The Institute of Medicine, 25-32). The healthcare industry was evolving too rapidly, and could no longer solely depend on such an antiquated information collection system.



18. Mainframe Computer System
1950 // Getty Images

The Digitally Based System // It was during the period of rapid transformation and growth in the second half of the 20th Century that experimentation with digital technologies in the healthcare sector began to occur. The digital systems that were evolving in and around healthcare would fundamentally change the methods with which caregivers utilized information for the effective delivery of care.

In the late 1950s, a few pioneering hospitals, most notably the Baylor University Medical Center, experimented with the use of large mainframe computers to improve communications and gather data electronically [Hannah, 31]. The experimentation with singular, centralized digital systems echoes back to the first implementation of the paper based information system: emphasis on a singular concentration rather than dispersion of information resources. The architectural response to these enormous systems was similar to that of the repository, a large, open space which was typically located away from the areas where care was being administered [Hannah, 31]. The initial focus of these technologies was to more effectively store large quantities of information which were initially recorded and then translated from the paper recording system.



19. IBM's Personal Computer (PC)
1981 // about.com

It was not until the late 1960s that these centralized mainframe systems began to be coupled with 'personal' computing modalities dispersed within the environment. In spite of their potential positive impact on the delivery of care, these systems only began to infiltrate the hospital in accounting and office areas, not making their way into caregiving spaces due to their unreliability, bulkiness, and high cost [Hannah, 32]. In 1967, the PROMIS project at the University of Vermont, a collaborative effort between physicians and information technology experts, began a research initiative to develop the first automated electronic medical record system [Pinkerton, 01]. The experimental electronic medical record (EMR) system was first implemented in 1970 at a ward in the Medical Center Hospital of Vermont. However, implementing these rudimentary EMR systems nationally within the healthcare environment proved so difficult (due to their size and complexity) that by 1980 only four such systems were in use [Pinkerton, 01].

In 1981, IBM's development of a personal computing device (PC), which was made possible through advances in silicon chip technology, signified the dawning of the Age of Information. During the remainder of the 1980s, the use of personal computers became more widespread in healthcare environments, and connectivity between



20. National Institute of Occupational Safety and Health Specifications for a Computer Display Terminal

1982 // Hannah



21. Nurse Workstation with Both Paper and Digital Recording Systems

2000 // Verderber

consoles was achieved through a connection to the large, centralized mainframe system [Jones Telecommunications and Multimedia Encyclopedia, 01]. However, due to the lack of portability of the initial personal computing systems and accessibility concerns, healthcare providers were unable to completely dispose of paper recording systems, instead relying on a mix of both to input and store data. Additionally, the initial cost of these early systems, the institutional cost of transitioning to them, their quick obsolescence, and lack of testing in the healthcare industry deterred providers from pioneering into the expanding computing field.

Since multiple systems (including patient record, billing, inventory control, and communication to name a few) had to coexist with each other in order for staff to work effectively, traditional nurse charting areas began to become overwhelmed with equipment, eventually leading to the expansion and/or reorganization of those spaces. In existing conditions where expansion was unable to occur, traditional charting areas were adapted to include individualized nurse computing stations in an effort to retain the visibility and centrality provided by those work areas [Hannah, 35-36]. Systematic redundancy between admissions, patient records, monitoring, billing, materials management, and organizational communication systems (which occurred due to the



22. Bedside Computer Station in the Spartanburg Regional Healthcare System Emergency Department Patient Room
2006 // Ruthven

specificity and lack of communication between their respective IT modalities] further fueled the technological clutter issues in this critical area (Lenz, Kahn 77-82). Accessibility and performance concerns also arose, as utilization of digital resources was restricted to the number of available platforms within a given unit.

In addition to the abundance of new equipment being implemented at nurse stations, patient care spaces began to become besieged with various forms of technological clutter. In an effort to bring computer terminals closer to patients and enable source data capture, workstations (termed point of care systems) began to first appear in patient rooms in the early 1990's. By reducing the distance between the patient and caregiver during data entry, point of care entry systems maximized the staff's ability to rapidly input and access information [Verderber, 220-221]. These systems typically remained coupled with other work stations outside of the primary care area to enable staff members the option of entering data in more private, workable conditions in the event that the patient was being disruptive or disturbed.

However, issues with safety, security, and privacy have occurred as a result of systems being placed as wall mounted units or on counter areas, forcing caregivers to have



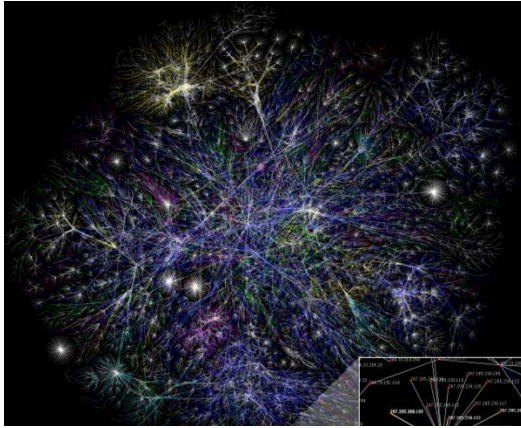
23. Wall Mounted Computer Workstation
2006 // infologixsys.com

their backs to the patient during data entry. For example, multiple instances have occurred in the emergency department at Spartanburg Regional Healthcare System, SC in which a nurse has been attacked by a disgruntled patient while their back was to him/her charting information (O'Hara, 01). Additionally, valuable counter space has had to be sacrificed in order to implement these systems, minimizing the available areas staff could utilize for the delivery of care (O'Hara, 01). The development of wall mounted, flexible arm systems in which to connect the workstation elements helped to combat these problems, but increased the overall physical impact that the systems had on the environment by generating more institutional clutter.



24. Decentralized Computer Workstation
2003 // Earl-Swensson Architects

An increase in decentralized nurse stations outfitted with computer input terminals began to emerge adjacent to patient rooms and other point of care areas as a response to staff privacy concerns with point of care systems and visibility issues with centralized nurse stations consoles. These stations provided caregivers the physical visibility required to monitor patients without sacrificing their ability to effectively record information digitally. It also reduced the potential for staff to disturb patients while charting and patients disrupting data entry by staff. If coupled with mirrored patient room configurations, the effectiveness of these stations was increased by enabling the



25. The Internet's Digital Brain
2007 // military-medical-imagery.com



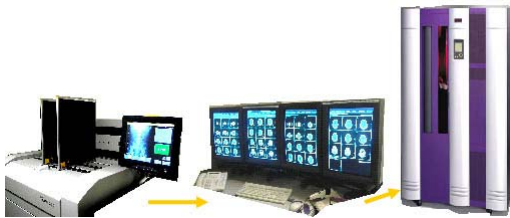
26. Magnetic Resonance Imaging (MRI)
2007 // military-medical-imagery.com

caregiver to have views to two separate patients from one vantage point. In the best case scenario, a hospital unit would be outfitted with a combination of centralized, decentralized, and point of care systems, enabling caregivers the flexibility to choose which station best accommodated their workflow for a given task. This finally helped solve the persistent problem of where a single medical record entry and retrieval point should be located for the differing needs of physicians, nurses and allied healthcare providers.

The capabilities and connectivity of the personal computing systems at these stations were expanded in 1991 with the inception of a revolutionary new form of telecommunications called the Internet. This powerful new digital network permitted computing technologies to become more interconnected by providing a universal digital platform to input, access, and transmit information. Personal computing technologies merged with telecommunications modalities to create client/server networks, allowing users to navigate across many different systems seamlessly from one input point, essentially ending the era of the mainframe computer (Jones Telecommunications and Multimedia Encyclopedia, 01).



27. Typical PACS Workstation
2004 // siemens.medical.com



28. Image Collection to PACS Workstation
to Central Mainframe Server
2004 // radiographicceu.com

In order to further liberate personal computers from their dependency on mainframe systems, they were designed to be more independently powerful, with marked improvements occurring in the areas of processing power, random access memory (RAM), monitor clarity, and storage capacity. Advanced digital storage modalities such as the Picture Archiving and Communication System (PACS), which was developed during the early 1990's, enabled radiologists to collect, interpret, distribute, and store the thousands of high-resolution, memory intensive images generated annually by advanced digital imaging modalities such as magnetic resonance (MRI) and computed tomography (CT) scanners. The research of University of Washington professor Yongmin Kim into PACS led to the first such system in the world being implemented at Madigan Army Medical Center in Tacoma, Washington in 1991. Typically a PACS system consists of a central server, which can be located on and/or off site, that stores a database containing the archived images and is connected to one or more image viewing workstations via the internet (Burnett, 01). The image viewing workstation is an all-important link in the PACS (Picture Archiving and Communications System) chain since it represents the interface between the system and the user. Due to the demand for visibility which requires several monitors (in order to see multiple



29. NEC Ultralite Laptop Computer
2004 // obsolete-computer-museum.org

images simultaneously), these stations are typically larger, and therefore take up more space than personal charting areas found in non-imaging areas of the hospital.

In addition to becoming more powerful, computers were also becoming more mobile during the early 1990's. The world's first 'notebook computer', the NEC Ultralite, was released in 1990 weighing in at less than 5 pounds, providing a physically compact and portable system that enabled caregivers to transport them throughout the environment with more ease. However, preliminary endeavors into mobile computing were plagued by inadequate processing strength and short battery lives which required they be close to an available power source at all times (Goodman, 01).



30. COW Corridor Alcove
2004 // military-medical-imagery.com

In order to increase the power and capabilities of mobile computing, computers on wheels (COWs) were developed to permit nurses to be able to chart and disperse medication within the patient's room without sacrificing processing power for mobility. The COW system enabled caregivers to utilize the more efficient, larger computers typically found at point of care, decentralized and centralized data entry stations, without being limited by their fixed position. However, these systems were still restricted by their demands for electrical power and generated frequent storage and



31. Remote Monitoring via Telemedicine
2004 // Getty Images



32. Say 'Ahhh' for Doctor Robot
2005 // tomorrowstrends.com

movement problems for staff due to their size, especially in existing facilities where the initial design did not anticipate their space needs (O'Hara, 01). Corridor alcove spaces to nest these systems began to develop, typically replacing fixed decentralized workstations adjacent to patient care spaces (Health Data Management, 01).

As rapid improvements in internet connectivity and speed occurred during the late 20th century, healthcare providers began to invest in telemedicine, enabling care delivery to occur from one site to another via electronic communications. Telemedicine has been utilized to conduct such activities as specialist referral services, patient consultations, remote monitoring, educational sessions, and consumer information services (American Telemedicine Association, 01). Although telemedicine activities could essentially occur at any computer terminal with internet access, hospital systems typically locate these services (including remote monitoring and distance education) within a centralized location, which can be on or off site. Since most of the interaction is recorded by a series of sensitive cameras in these environments, lighting and sound levels must be easily controllable. Telemedicine's mobility and versatility also improved by integrating IT components with robotic elements, creating a 'virtual doctor' which could conduct a verbal consultation with patients.



33. Wireless Personal Data Assistant (PDA)

2004 // Getty Images

Significant IT advances at the commencement of the 21st century enables caregivers to input, access, and track information with more efficiency than ever before by becoming more compact, high-speed, and wirelessly connected anywhere they are needed. Wireless network technology permits doctors and nurses to enter data ubiquitously into modalities such as personal data assistants (PDAs) and tablet PCs, unrestricted from typical data entry areas. However, inconsistencies from these emerging technologies prevent them from becoming the solitary method for data recording, and they remain most effective when coupled with a 'wired' system (Gilfor, 01). Additionally, the overall minute size of these devices enables them to be highly portable, but limits the caregiver's ability to effectively transmit or retrieve information on patients in instances when large amounts of information, or larger representational media, is required.

The Reactive Response of Healthcare Architecture to Technology

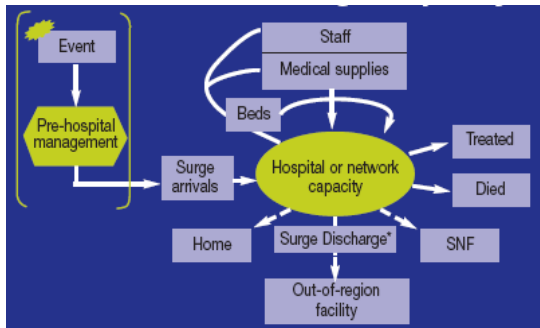
It is not a coincidence that during the previous historical overview of information technology in the healthcare industry that no instances were mentioned where an architectural environment proactively influenced or was considered exclusively during the design of that system. In spite of the methodological paradigm shift from a paper based system to its digital successors, 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 at best 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. This 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.



34. Unpredictable Environmental Surges
Create an Increase in Patients + Staff
2007 // Ruthven

Compromised Flexibility and Performance // In the 21st Century, the ability for a healthcare facility to rapidly adapt to changing conditions is critical to its success. With current healthcare utilization rates at all time highs and an ever increasing aging population, intense pressures are mounting to provide higher quality care, more consistently, with fewer resources. Additionally, environmental and political instability are increasing the potential for mass casualty event surge situations, causing healthcare systems to reorganize themselves more effectively in order to adequately adjust to these changing conditions. Improved ways to employ and integrate information systems into healthcare services and settings can help address some of these issues.

While the implementation of digital systems has created significant improvements over the paper-based system, provider's continuing utilization of fixed position, single user computing stations have limited their ability to adapt effectively. This problem is best illustrated during worst case scenarios such as mass casualty events, when the degree to which the environment is being utilized is pushed to its limits. Once the influx of patients begins to arrive at the hospital or network of health care facilities, a leading



35. The Determinants of Surge Capacity
2004 // Agency for Healthcare Research + Quality



36. Nurse Waiting to Use a PC Station
2002 // infologixsys.com

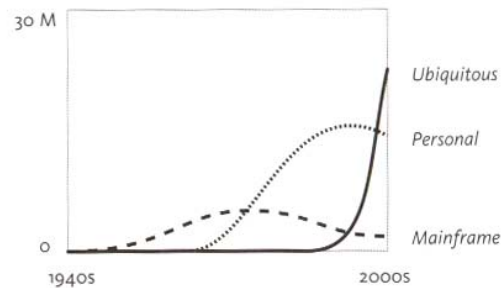
determinant of the surge capacity for a given facility is the availability of hospital resources. The number of patients who can be treated during a surge event is determined by three main factors, including as the number of staff, access to medical supplies (including technological communications resources), and the circulation of beds (The Agency for Healthcare Research, 03). Personal computing workstations which are designed to regulate usage to a single user limit two of the three main determinants of surge capacity, impeding the ability of a facility to increase staff numbers effectively by minimizing access to communications resources. The reactive environmental response of providing individualized work areas for each personal computing modality encourages this problem by inhibiting each station's ability to accommodate an increase in staff activity. Essentially, it is the 'personal' nature of these systems and workstations that limit their abilities to accommodate more staff presence within the environment.

Performance issues can also be related to the implementation of generic, fixed position, 'personal' computing modalities in the healthcare environment. Increased interest in wireless technology over the past few years has resulted from providers desire to 'cut the cord' in order to enhance their operational performance. However,



37. The Intersection of Information Recording Systems at the Central Nurse Station

2007 // nd.gov



38. Major Trends in Computing

2004 // McCullough

due to coverage inconsistencies and issues displaying large media information to patients, the wireless systems have remained dependant on the older, non-ubiquitous technological infrastructure. This problem is further amplified by the slow adoption of electronic medical records as a sole means of recording medical data, instead mixing high-technology with the antiquated paper based system [Davis, 05]. As of 2006, only 12% of healthcare providers have completely switched their systems over to electronic medical records, with outdated paperwork methodologies still weighing down the greater portion of the industry [Frist, 01]. By mixing these various developmental stages in information gathering together, the healthcare environment has become overwhelmed in order to create proper conditions for each system to work. The embodiment of this problem occurs in several areas within healthcare, but most notably at the central nurse station, where it is common to see paper filing systems piled next to digital workstations. The result is that neither the hybridized information system nor the environment it operates in work to optimize the delivery of care due to prolonged paperwork burdens and increasingly cluttered architectural settings. While the rest of the world moves towards a ubiquitous form of computing, as evidenced in the work of technological visionary Mark Weiser and discussed in the next chapter, the healthcare industry truly resides in a state of self-imposed limbo.



39. Technologically Overwhelmed Patient Care Environment
2007 // Getty Images

Degradation of the Healing Environment // The idea of patient centered care has redefined the way in which healthcare providers operate in the 21st Century. The prime aspects of patient-centered care include respect for a patient's values, coordination/integration of care, health education, physical comfort, emotional support, family involvement, and continuity of services [Bezold, 11-12]. The architectural implications of this care model consist of supporting these components through the creation of a holistic healing environment, enabling patients to mend by increasing their level of comfort and control over their surroundings. The inclusion of various information technology modalities into primary patient care areas potentially undermines the level of comfort and control for patients by overwhelming their environment with technological clutter. Additionally, many of the IT systems which are designed to remedy patient ailments can also harbor infectious agents, a result of their inclusion of numerous intricate surfaces, seams, and joints which are nearly impossible to sanitize. Studies indicate that computer keyboards and mice are the most common sources of cross-contamination and infection spreading in hospital environments [Hartmann, 7]. In order for the architectural environment to take back control over the technological systems which compromise its effectiveness, an amalgamation of



40. The Computer Keyboard: Breeding Ground for Infection
2004 // Getty Images



41. The Central Processing Unit: Friend of the Nosocomial Infection
2004 // Getty Images

both elements must occur in an effort to simplify, streamline, and improve their collective impact on patient outcomes.

Towards a New Model // The creation of the patient medical record in the early 20th Century signified the importance of organizing and cataloging information for the effective delivery of healthcare. 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. Unlike the supportive role that it employed during the paper based system's origin, the fundamental function of healthcare architecture during the digital age has remained a reactive one. This has resulted in a disconnect between the design of healthcare architecture and these advanced information technology systems, hindering their collective ability to adapt to changing conditions, deliver care effectively, and provide a suitable healing environment for improved patient outcomes. 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. Experimentation with environmental integration of information technology has been occurring in many sectors of architecture in the past few years, yielding important benefits that have the potential to transcend into the healthcare industry.

CREATING A NEW LINKAGES THROUGH DIGITAL ARCHITECTURE

Interactivity becomes a remedy for architecture, which as a discipline has ignored usability, performance, and inhabitation in its quest for attention seeking novelties of form. Architecture needs to rejuvenate itself with interaction design.

Malcolm McCullough

Author of "Digital Ground: Architecture, Pervasive Computing, and Environmental Knowing" (1963 -)



42. Focus on Architecture
2007 // Ruthven

In the 21st Century, buildings are improving upon their ability to adapt to changing conditions, provide accessibility to data outlets, and streamline the environment by integrating information technology systems into the framework of their architectural design. Innovations across various fields of architecture which fuse technological modalities with building elements can be employed by the healthcare sector to remedy problems associated with the current lack of environmental and information systems integration. Dissolving the disconnect between architectural environments and IT systems can create a more holistic, digitally integrated setting in which to deliver care more effectively by improving the facility's capability to adapt to changing conditions, operational performance, and ability to provide a technologically sophisticated healing environment. An appropriate healthcare setting in which to test the capabilities of

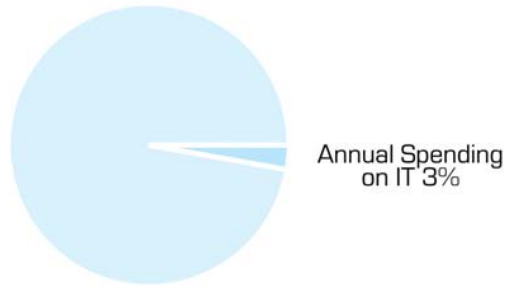
digitally integrated environment should exemplify a set of characteristics, including fast pace care delivery dependent on the rapid utilization of information, large quantity/disparity of technological systems used to administer care, high turnover rates which require quick sterilization of spaces, and unpredictable volumetric shifts which require flexible environments/systems.

Intelligent Architecture in the 21st Century



43. A Blurring of Boundaries: Cyberspace
2007 // ocf.berkeley.edu

The description of architecture as 'intelligent' can be defined in several different ways. For example, this concept could apply to building systems management, self-regulation of heating and cooling levels, or response to climatic conditions. Along with the rapid technological advances in the 21st Century, the coupling of 'intelligent' with 'architecture' has adapted this terminology to include a new definition: a building which responds to stimulus through digitally enabled, environmental cognizance (McCullough, 108-109). The boundaries between digital technology and the physical environment are beginning to blur, as evidenced in evolving technological terms such as 'cyberspace' and 'ubiquitous computing'. The ways in which environmental and technological components manifest themselves is also starting to amalgamate into hybridized digital building elements, which will be the focus of exploration in this section. While there is no clear area within architecture that is making the most progress in technological integration (examples exist from stadium design to residential applications), the healthcare industry undoubtedly lags behind. This stems from several causes, most notably the lack of overall healthcare funding that is allocated for



44. Annual Funding Allocated to IT in the Healthcare Sector

2006 // Institute of Medicine

information technology implementation (a mere 3% as compared to 10% in banking for example) [Davis, 04]. Therefore, the intent of outlining various modalities which are developing in areas outside of healthcare is to highlight features which could be translated into the medical sector, remediating problems associated with the disconnect between the physical environment and its respective technology. Through utilization of these digitally integrated, architectural elements, the quality and effectiveness of a healthcare facility can be improved through increased capability to adapt to changing conditions, improved operational performance, and ability to provide a technologically sophisticated healing environment for patients, families, and staff.

Improved Flexibility and Performance // The ability for a healthcare facility to rapidly adapt to changing conditions and remain at a level of optimal performance is critical to its continuing success. Under any conditions, a care facility's quality and effectiveness is directly linked to its ability to support the input, access, and transmission of information within its environment. Therefore, utilizing modalities which maximize accessibility to digital resources can empower caregivers by providing them with a platform to make use of information rapidly and ubiquitously. Rather than limiting data



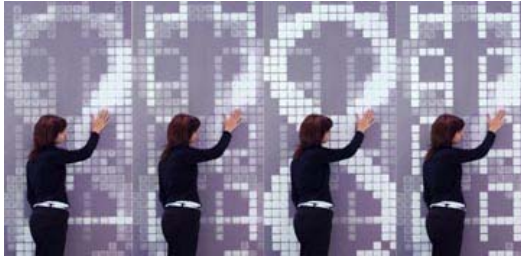
45. Multi-touch Interaction Surface
2005 // cs.nyu.edu/~jhan/



46. Nissan Interactive Mirrors Exhibit
2007 // howdesign.com

accessibility to a few disparate computing stations within the environment, spatial boundaries can be redefined as digital connectors. Through the employment of environmentally integrated interface elements, a high level of computing pervasiveness can be achieved.

The *Multi-touch Interaction Surface*, a 16-foot-long rear-projected interactive wall display, is an example of an interface system which has been integrated into an architectural element. The display has the ability to sense multiple points of touch, allowing its users to interact with both hands at the same time. By enabling this increased level of interaction between the user and the system (as opposed to more common single point of contact systems), its level of efficiency, usability, and intuitiveness is increased (Han, 01). Additionally, since the entire surface can detect a point of contact, a multitude of potential users can utilize the system simultaneously, all within one platform. Another example of an integrated digital wall element is the *Infiniti Interactive Mirrors* exhibit, which presents an immersive video and motion design presentation when users interact with the surface. Navigation through a series of simple menu options is controlled by motion sensors which detect user movements. Nikolai Cornell, the project's executive producer described the installation as "so large



47. Interactive Wallpaper
2005 // interaction-ivrea.it

that you really feel like you are a part of it. You're not tethered to a mouse or keyboard. Just walk forward and back and wave your arms to navigate" (Taute, 170). Various other digital modalities such as *Interactive Wallpaper* provide similar functional characteristics, but can be applied to existing walls as a surface treatment, rather than becoming the physical wall itself (Buzzini, 01).

The potentials for the implementation of these systems within the healthcare environment are enormous. Liberating caregivers of fixed position, single user computing stations and replacing them with environmentally integrated, pervasive interface elements would alleviate the performance and adaptation concerns discussed in the previous chapter with the current implementation of 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. Germ transfer from physical interaction with these wall systems can be neutralized through utilization of motion



48. Allianz Arena's Digital Skin
2005 // Herzog and de Mueron

sensor technology, enabling staff members to access resources without actually having to touch anything. These monolithic surfaces also have the potential to become more easily cleanable with compatible cleaning procedures and agents, rather than the current mix of 'electronic safe' and normal sanitization products.

Coupling wired, digitally integrated environmental platforms with portable, wireless data modalities would create a solid technological system by balancing mobility with reliability and scale. Furthermore, the potential for multiple users to utilize a single wall interface increases the amount of available access points exponentially, expanding the flexibility of the caregiving environment by facilitating fluctuations in staffing levels during circumstances such as mass casualty events.

The ability to extend the capabilities of a healthcare facility beyond its interior spaces can be achieved by integrating digital elements into the fabric of a building's façade. The incorporation of digital technologies into exterior architectural surfaces enables entire facilities to be re-conceptualized as information transmitters. Herzog and de Mueron's Allianz Stadium in Munich Germany demonstrates the potential benefits of this type of environmental integration of technology. The building's digitally integrated



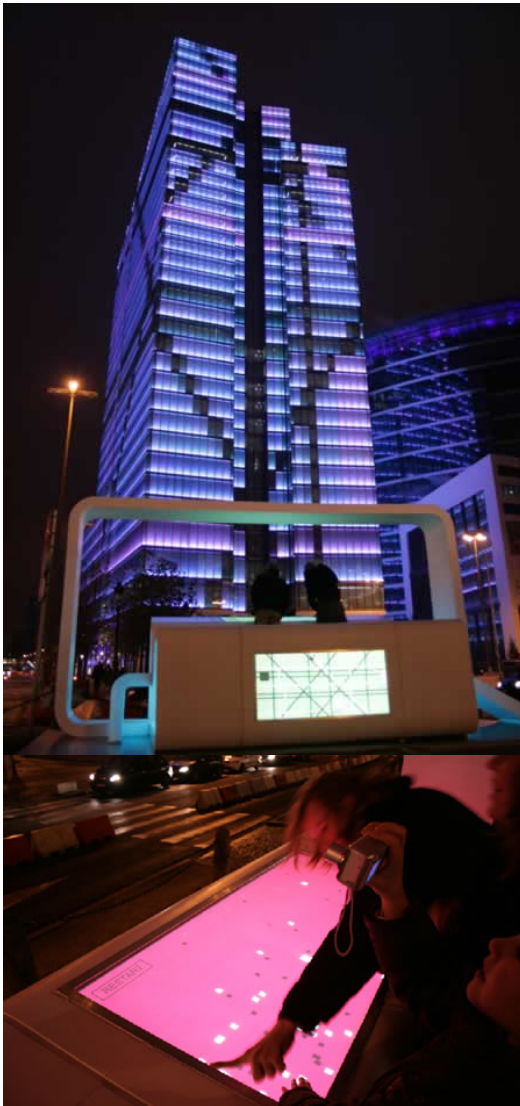
49. Informational Digital Skin
2005 // cycleries.com



50. Interactive Digital Community Element
2006 // [Plensa](http://Plensa.com)

skin is able to transmit information by way of colored lighting panels that indicate which of the two local football teams have a match at the stadium. When the teams face each other, the façade transforms to become a patchwork of both colors [Chevrier, 272]. A digital façade can also transmit other forms of information such as advertising, news, and alerts by becoming a technological billboard. The Nasdaq Building in New York City steals attention from over stimulated urbanites in Times Square through the use of a mixed media façade display that wraps the entire exterior of the building. In both cases, the building becomes a conveyor of knowledge to the public at large, a feature which could be utilized by a medical facility to strengthen its ability to communicate information for anything from community awareness to health education.

Digital building elements can also create new connections with the community by becoming interactive features. The potential power of this relationship is evidenced in the popularity of Chicago's Crown Fountain by sculptor Jaume Plensa, in which an interactive display projects an image of a Chicagoan, who then proceeds to 'spit' a fountain of water down onto anyone brave enough to wander close to the installation. The power of the architectural piece lies in its ability to capture the life and vibrancy of



51. Touch Interactive Façade Installation
2006 // interactivearchitecture.com

the people who interact with it (Boyer, 01). Another example of an interactive digital building element is the *Touch* installation by the Laboratory for Urban Architecture. Users are encouraged to animate a façade via a control point touch screen across the street, enabling a sense of unity and freedom of the physical manifestation of the architecture within its environment. By locating interactive installations at a visible distance adjacent to a healthcare facility (or within the framework of the façade itself), these vital characteristics can begin to translate into the healing environment, increasing the phenomenological sense of hope and purpose for its patients. Additionally, interactive digital elements can be designed to act as informative displays in times of need through the use of color and patterns. 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 (similar to the Allianz Arena concept).

Technologically Sophisticated Healing Environment // 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 physical



52. Streamlined Environment: Z. Island Kitchen

2006 // dexigner.com



53. Streamlined Environment: Z. Island Kitchen Controls

2006 // dexigner.com

volume and quantity of these technological objects, as well as their disruptive acoustical and visual “noise,” can make an intimidating and complex situation even more incomprehensible. Additionally, the various technological modalities introduce a myriad of intricate surface areas into the healing environment which are difficult to sanitize, compromising its overall sterility and safety by harboring infectious agents. The fusion of architectural elements with technological platforms can remedy these issues by simplifying, streamlining, and improving their collective ability to improve patient outcomes. Liberating the physical environment from the spatial ramifications of technological clutter can also improve the delivery of care by expanding available work areas for staff. Furthermore, integration of digital identification modalities into the architectural environment can further expand its users control over their surroundings through the generation of a personalized, secure, quantifiable level of accessibility to pervasive computing elements.

A synthesis of architectural style with technological functionality drove the design of the Z-Island Kitchen, by architect/artist Zaha Hadid for Dupont. The main island unit evolves from a horizontal cooking and eating surface into a vertical, imbedded digital interface which consists of an LCD screen for TV or computer use. The island’s work



54. Radio-frequency Identification Device - RFID

2006 // designer.com



55. Biometric Hand Scan Identification

2006 // designer.com

surface was enhanced through the integration of LED lights into the Corian countertop, informing the chef(s) of cook times, current temperatures, and preparation instructions (Ozler, 01). Since most of the technological elements are integrated directly into the continuous construct of the counter surface, their spatial impact on the environment is minimized, with the added bonus of simplified cleaning and sanitation. Additionally, instead of defining clear zones where specific activities would occur along the counter, the designers sought to combine and overlap the capabilities of potential work areas. The resultant was an increase in the overall level flexibility afforded to the user, allowing her/him to define the event rather than the other way around. The potential translation of these architectural and technological innovations into the healthcare environment would remediate sanitation and clutter issues by composing a solution which melds elements into one seamless, simplified, flexible work area.

Paradoxically, the main strength of ubiquitous computing is also its greatest weakness. Omnipresent, unrestricted digital access would create a state of infinite expansiveness, overwhelming its users with a sensation of the loss of control. For example, if access to digital information is granted at any given point within a defined environment (via a



56. Interacting with ADA: The Intelligent Room

2006 // interactivearchitecture.com

system of integrated interface elements), that state could be defined as the ultimate embodiment of digital flexibility. However, it is important to note that this infinite level of digital flexibility could also be defined as a state of chaos, resulting from the lack of structure and hierarchy which is needed to regulate accessibility and maintain control [McCullough, 14-17]. If digital connections 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.

The interactive environment ADA (the Intelligent Room), created by a team of architects and interaction designers at the Institute of Neuroinformatics Zurich, embodies the potential impact recognition technologies have over the control and activation of architecturally integrated digital components. ADA acts analogously to a human's central nervous system, using a plethora of identification technologies (cameras, motion sensors, pressure actuators, and biometric scanners) as its digital



57. ADA: Personalized User Interface via Proximity Sensors

2006 // interactivearchitecture.com

nerve endings to detect stimulus from users. ADA becomes a functional creature, programmed to balance visitor density and flow, identify, track, guide, and group specific individuals, and then play interactive games with them (Bullivant, 87). While the installation is purely for entertainment purposes, several of its unique characteristics present opportunities for implementation in the healthcare environment.

Regulation of, and accessibility to, information is critical to the safety, security, privacy, and control caregivers must maintain over their surroundings. While pervasive, architecturally integrated digital interface elements can optimize accessibility to digital resources, the private and personal nature of those resources requires a significant degree of protection be enforced. Advanced identification technologies can be employed to filter potential user typologies into different categorizations, such as patient, family member, visitor, nurse, doctor, etc. Each typology could be customized to enable a level of accessibility and provide outlets to functions that may apply to one individual, but not others. For example, as Doctor Bob approaches a digital wall interface, he is scanned (biometrically in this case) and the surface lights up providing access to patient electronic medical records, medication acquisition, and scheduling

options. When Mr. Dave, a patient of Doctor Bob, encounters the same wall interface, his options are restricted in areas with privacy concerns (medication and scheduling), regulated in others (access is granted to his EMR only) and expanded upon based on his possible needs (entertainment, educational resources, etc). As Mr. Dave finishes his computing session and walks away, Ms. Trubble decides she would like to learn a little bit more about Mr. Dave's medical condition. To her dismay, any information concerning Mr. Dave disappears with him, and she is only presented with generalized options granted to the general public (entertainment, educational resources, etc). The adaptation of the digital interface to various potential users increases their feeling of comfort with these environmentally integrated systems by generating more personalized connections. Additionally, by utilizing identification technologies the environment can ambiently track and respond as inhabitants and equipment move through its digital constructs, enabling it to ambiently perform tasks (as determined by staff) and provide an increased level of security and control for patients, visitors, and staff. Essentially, imbedding these identification technologies into the architectural environment would add a layer of safety, comfort, and control to the performance and flexibility characteristics inherent in ubiquitous, environmental interface elements.

Towards a Digitally Integrated Healing Environment // By integrating various types of technology into their architectural design, buildings are evolving into intelligent environments that serve humans by creating pervasive access to information, transmitting data in an entertaining and educational manner, and increasing the levels of safety, comfort, and control. By merging technological modalities with physical elements, the performance, flexibility, and sanctity of the healing environment can be enhanced, ultimately generating a more efficient architectural setting for the effective delivery of care. Although all forms of healthcare architecture could benefit from the integration of technological elements, a suitable typology to express the extent of the capabilities should embody a set of characteristics. A care environment which contains fast paced care delivery would best illustrate the benefits of this fusion. This kind of setting would be dependent on the rapid utilization of information, utilize a vast range of technological systems to administer care, experience high patient throughput which requires quick environmental turnaround, and face unpredictable volumetric shifts which require a high level of flexibility. The emergency care environment embodies this set of characteristics, and is therefore an appropriate vessel to implement the thesis proposal.

DIGITAL ARCHITECTURE'S ROLE IN THE DELIVERY OF EMERGENCY CARE

Now is the time to take a cold, hard look at your emergency department. Is your strategy for the future to delay and wait for that impending crash? Or, is it your strategy to develop emergency care services, systems, and environments that will flourish and consistently serve the rapidly changing needs of your community now and into the future?

John Huddy, AIA

Author of "Emergency Department Design: A Practical Guide to Planning for the Future" (1962 -)



58. Focus on Architecture + Health
2007 // Ruthven

The emergency care environment is a suitable healthcare typology for the architectural integration of information technology due 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. These problems can all be related in various ways to inadequate throughput methodologies which are the result of inflexible facilities outfitted with obsolete IT systems. An analysis of the basic throughput process highlights critical focus areas within the emergency care environment that would benefit most from the integration of IT including patient care spaces, staff work areas, and entry triage.

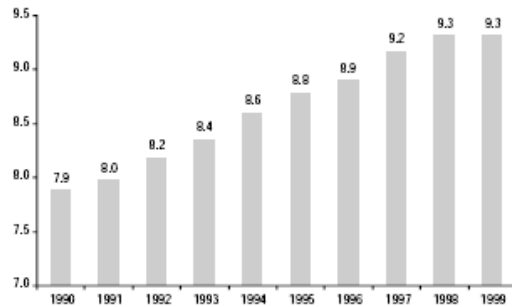
These three focus areas all incorporate information technologies in different ways, but share a commonality in that they do little to integrate those technologies into the framework of the environment. Appropriate IT integration into each of the selected focus areas within a comprehensively designed medical facility, coupled with a strong care giving methodology, can create a safer, more efficient environment for the delivery of emergency care by improving the overall throughput process.

The Contemporary Crisis in the Emergency Department



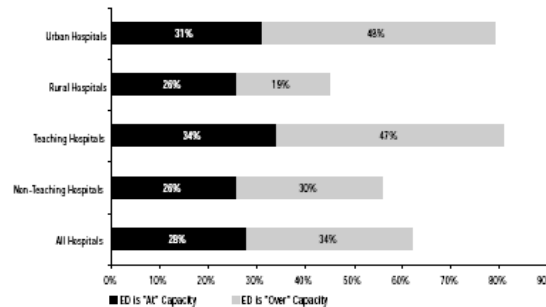
59. The Fast Paced Emergency Care Environment
2007 // gettyimages.com

The importance of rapidly utilizing data for the effective delivery of care in the emergency department makes it an ideal healthcare setting for the integration of information technology. With overall number of facilities diminishing, and the rate of utilization increasing, the national emergency care system has been pushed to its limits [American Hospital Association, 03]. Contemporary emergency departments are beleaguered by several serious problems related to inadequate throughput which compromise their quality and effectiveness. 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 natural and manmade mass casualty events.



60. Median Average Age of Healthcare Facilities in Years

2001 // CHIPS: The 2001 Almanac of Hospital Financial & Operating Indicators

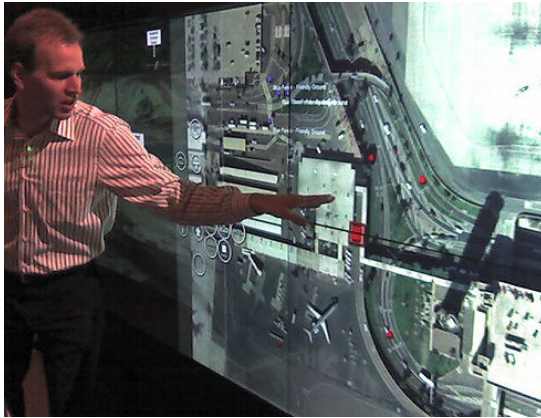


61. Percent of Hospitals Reporting ED Capacity Issues by Type of Hospital

2001 // The Lewin Group analysis of AHA ED and Hospital Capacity Survey, 2002

The Rising Tide // Emergency departments in the United States have been in turmoil for several decades, with problems primarily stemming from shifts in population and healthcare management that have increased the demands on a decreasing number of aging facilities. Population growth (especially in geriatrics) coupled with a dramatic increase of uninsured citizens (13.4% in 1990 – 15.7% in 2005) has led to overutilization of the ED, which represents the primary point of care for that demographic group (United Health Foundation, 01). Over the past decade, ED visits have increased more than 20%, resulting in overcrowding that sets the current national average wait time at 3 hours, with more than half of patients waiting 2 to 6 hours (Lott, 02). ED overcrowding forces providers to divert patients to other facilities during periods of peak utilization, often at the expense of their health status.

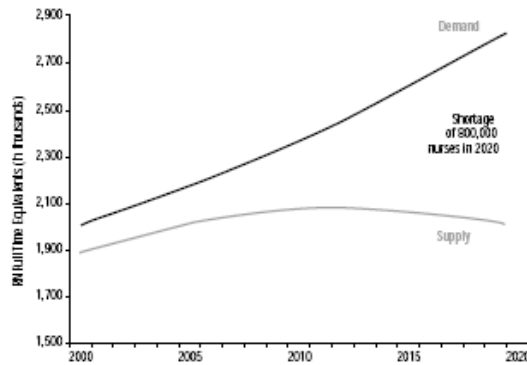
Additionally, the majority of people who use the local ED as their primary point of care are without insurance, yet fall above the government defined poverty line that enables usage of Medicaid (20,000\$/year for a family of 4 in 2006) (US Department of Health and Human Services, 01). This creates a situation where people require medical assistance, but are unable to reimburse the hospital for services because they



62. Presenter Using a Digital Display Wall as a Compliment to his Verbal Explanation
2006 // flickr.com

lack financial means, placing economic strain on providers. A correlation between adults (who constitute 80% of the total uninsured population) and lack of education is evident, with less than 14% indicating that they have a college degree (Kaiser Commission, 01). The lack of education results in difficulties admitting and processing patients, as well as effective continuing and follow up care once they are discharged. These problems are compounded by a lack of educational and communication tools needed to convey this information clearly and effectively to a relatively uneducated and inexperienced population. Information technologies can help by enabling the use of user friendly educational displays to compliment verbal communication. Environments must be carefully designed to accommodate this population, as confusion in understanding and finding ones way through the both the system and setting can contribute to the overall chaos, stress, and length of the healthcare experience, ultimately stymieing the throughput process.

A leading contributor to the overcrowding epidemic is inadequate throughput processes that, when coupled with increasing patient volumes, create a disastrous combination which clogs the care delivery system. Factors contributing to inadequate throughput include lengthy information input and distribution methods, superfluous







63. Supply vs. Demand for Registered Nurses 2000 - 2020

2002 // Bureau of Health Professions, National Center for Health Workforce Analysis

steps in the triage process (which can be a result of outdated information technology systems), lack of sufficient staff, slow transition to full usage of electronic medical records, complex and inefficient departmental layouts, and limited access to resources that enable rapid data entry. Congestion in the system is detrimental to the health and well being of patients, family, and staff members in the emergency department (Lott, 01). Long wait times lead to dissatisfaction, anxiety, and emotional deterioration for patients and family during circumstances that are already stressful at best. Furthermore, overcrowded areas often force conflicting populations of people to intermingle (sick vs. healthy, victims vs. perpetrators, opposing families, etc), dramatically increasing an already tense environment. Since the healthcare experience begins for many patients in these unnerving conditions, the resulting discomfort and angst sets the tone for their entire visit. Additionally, staff can have difficulty distinguishing between patients and visitors as a result of population mixing and large crowds in centralized waiting and circulation areas, causing their stress levels to rise from confusion and lack of control over the environment.

The shortage of nurses and medical specialists place an additional burden on the delivery of care in the ED by leading to a reduction in the number of staffed beds

Care Setting	Every Hour of Patient Care Requires:
Emergency Department Care	 1 Hour of Paperwork
Surgery and Inpatient Acute Care	 36 Minutes of Paperwork
Skilled Nursing Care	 30 Minutes of Paperwork
Home Health Care	 48 Minutes of Paperwork

64. The Paperwork Burden

2001 // PricewaterhouseCoopers Survey of Hospitals and Health Systems

downstream in other departments within the facility, which in turn contributes to problems such as overcrowding, increased wait times, ambulance diversions, and patient length of stay. Current estimates indicate that approximately 168,000 healthcare positions are unfilled, with trends projecting an increasing gap in the next decade of more than 400%. This has lead healthcare providers to minimize staff intensive inpatient admission to the greater hospital system, resulting in lengthened emergency department observational stays and exponentially increasing congestion in that environment. Additional strain stems from the large range of treatments that are administered in the ED (more than 1,500 annually) and the reality that caregivers must be prepared for anything and everything to occur during a typical shift. The large disparity and quantity of illnesses that caregivers face in the ED is reflected in the enormous amount of paperwork that they face, which currently stands at 1 hour per patient (American Hospital Association, 07).

Ironically, the same problems that are caused by inadequate staffing also contribute to the high rate of burnout among existing staff. With no indications that shortages will subside in the near future, providers have to shift their focus to doing more with less. It is in this area that the integration of digital technologies into the framework of the



65. Swedish Medical FED: Rapid Eye Assessment Station with Clustered Visitor Waiting Beyond
2006 // Callison Architects



66. Swedish Medical Issaquah FED, Seattle WA with Clustered Visitor Waiting (Beige)
2006 // Callison Architects

care environment could help facilitate a solution to this problem. Digital information technologies can help empower nurses with the ability to care for a larger volume of patients more seamlessly, without sacrificing the quality of care. For example, simply switching over to an electronic medical records system would reduce the tremendous amount of paperwork which puts a strain on a caregiver's time. Coupling this switch with more ubiquitous access through adequately positioned integrated architectural interface elements, and the safety and control generated by imbedded recognition technologies, will further strengthen the environment's ability to allow fewer staff members to accomplish more tasks with better outcomes, in less time. Additionally, the fundamental organization of the physical environment must be re-conceptualized in order to help address the issues of overcrowding and staffing shortages in other ways.

Deconstruction of the centralized waiting area into clustered waiting spaces is one way to combat these problems. Swedish Medical's Issaquah Freestanding Emergency Department in Seattle, WA has implemented this environmental response to overcrowding with much success. Visitor waiting areas are dispersed along the exterior of the building into small clusters adjacent to patient examination spaces which can accommodate 3 - 5 people comfortably. A level of privacy and respite can



67. Swedish Medical FED: Patient Exam Room with Digital, In-Room Registration
2006 // Callison Architects

be achieved during the waiting process by arranging the environment in this manner (Faulkner, 01). While this arrangement creates a dramatic improvement over large, chaotic centralized waiting spaces, connections to digital resources for patients and visitors do not exist, yet could be integrated into the surrounding environment to further strengthen their sense of comfort and control over the situation.

One area where inclusion of technology has been considered in the design is the patient examination space. Wait times have been cut in half by utilizing a digital, in-room registration system that allows Swedish Medical to advertise it as a 'no-wait' emergency department. While the facility does not completely live up to its utopian view of a 'no wait' environment, the quantity of people and amount of time they have to wait has been reduced noticeably (Faulkner, 01).



68. Swedish Medical FED: Central Nurse Station with Digital Patient Monitoring
2006 // Callison Architects

Another area where technology plays an integral part in the operations of the facility is in the staff work core. The project was an upfit of an existing office building, and as a result had to conform to structural systems and the compact footprint of the old facility. Problems with clear staff visibility to all of the patient exam rooms in the staff core resulted. The issue was resolved by incorporating digital monitoring equipment



69. Airport Digital Display Wall
2006 // Narita Airport, Japan

into a central, enclosed nurse station as shown in figure 68 (Faulkner, 01). While this does not illustrate the ideal condition (where digital and physical visibility would be maintained), technological elements were integrated into the setting in order to remedy the problem.

Healthcare is Not Alone // Similar staffing and throughput problems are occurring in other business sectors, with the most notable being the air travel industry. Airports represent the purest embodiment of an environment designed to facilitate throughput. People literally travel to an airport because they desire to be somewhere else. In order to improve throughput, minimize overcrowding, and provide a level of security to its customers, the airline industry has been at the forefront of integrating IT elements into its environmental and operational design.

Realizing that existing procedures were too complex and required a plethora of steps to complete, airlines initiated the SPT (Simplify Passenger Travel) objective across the international air travel industry in February of 2000. Airlines have been making changes to their processes in the recent years by combining and simplifying the complex procedures required to utilize air travel. Through the use of automatic check-

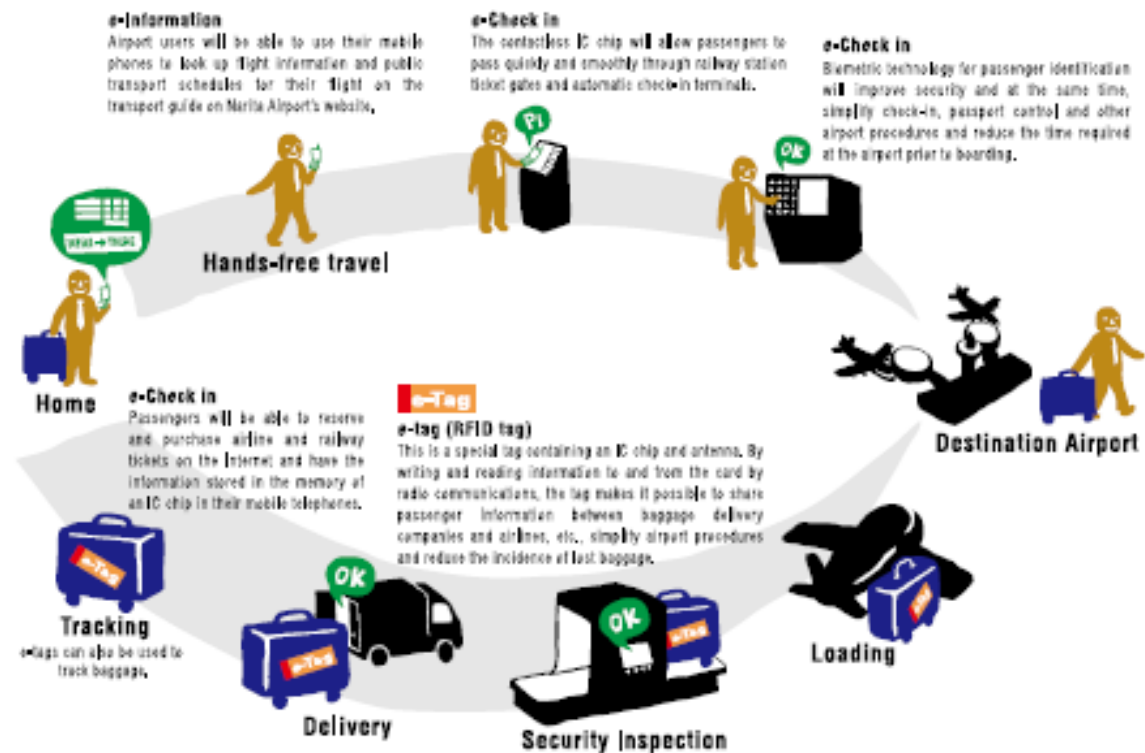


70. An eCheck-In Kiosk with Biometric Retinal Scanner
2006 // Narita Airport, Japan

in machines, biometrics, and electronic records for storing travel data, airports have been able to process people with more efficiency, without compromising the heightened level of security brought on by the attacks on September 11th or increasing staff levels.

Among others, the Narita Airport in Japan has been a launching pad for the global SPT objective, carrying out experimentation with eCheck-In and eTag - Hands Free Travel programs. The eCheck-In program utilizes digital kiosks and biometric scanning technologies to streamline the check-in process, saving time for employees to devote to more precise and thorough security checks. Although the program resulted in marked increases in efficiency and customer satisfaction, it is important to note that their physical implementation as single-user kiosk elements minimized their potential by limiting accessibility and still requiring wait times (albeit much less than before they were instituted). The eTag program was also initiated to improve the facilities ability to track and monitor the millions of pieces of luggage moving through it each year. As opposed to conventional barcode strips which can be damaged during flight, RFID tags were attached to each piece of luggage. The program was a huge success, improving the rate at which the airport was able to successfully process and recognize individual

pieces of luggage from 90% (the figure is around 70% globally) to 98.84% (Narita Airport Annual Report, 52). In order to monitor the items effectively from a centralized location, a 'baggage control room' was developed. Collectively, these systems are part of a larger e-Airport initiative which seeks to redefine the future of international air travel by simplifying and streamlining the process and environment.



71. e-Airport Concept
2006 // Narita Airport, Japan

A similar approach could be employed by the healthcare industry to remedy problems in the emergency care environment. Digital eCheck-in machines could be integrated into the architectural setting of the triage entry space, simplifying and expediting the primary registration process down to the swipe of a form of identification. Upon completion of the primary registration process, a system analogous to the eTag program could be used in the form of wearable, disposable bracelets given to each person in the facility. This would enable staff to track and monitor all inhabitants present in the system, increasing the levels of security markedly. Additionally, equipment and supplies could be tagged with similar technology, minimizing the amount of time staff spend 'hunting and gathering', as well as the level of theft for those items.

While in many ways still in their infancy, the power of technologies utilized in the e-Airport initiative will only be strengthened by their continuing fusion with the surrounding environment. Just as Dr. Plummer took queues from local industry in his adoption of the pneumatic tubing system, the emergency care environment need look no further than the air line industry for inspiration towards optimizing its throughput potentials.

Disaster Preparedness for Mass Casualty Events



72. Terrorist Attacks of September 11th, 2001 on the World Trade Center, NYC
2001 // Getty Images

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. The healthcare system in the United States has made progress over the past five years, but a comprehensive assessment of the public health preparedness for mass casualty events conducted in 2004 by the Bloomberg School of Public Health at Johns Hopkins University, Baltimore made some relevant claims to the contrary. The study concluded that disaster response plans are in place in the majority of states (94%), but that fragmented communications systems, inadequate training, and lack of properly prepared facilities make it difficult for state governments to adhere to their plans. 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.



73. Caregivers Waiting for Patients to Arrive, Downtown Hospital NYC
2001 // Getty Images

Expansion of Services // An inability for emergency care providers to expand their facility's capabilities during volumetric surge events limits their ability to provide care during times when it is needed most. The degree to which the environment can be inundated with patients was demonstrated during the terrorist attacks on the World Trade Center on September 11th, 2001 at New York Presbyterian's Downtown Hospital in lower Manhattan. On a typical day, the emergency department treats between 5 - 10 patients per hour. That average quickly ballooned to 175 patients per hour during the attacks. In all, the hospital treated over 1,500 patients from the incident, with 1,200 of those occurring on the first day and 350 within the first two hours (Lower Manhattan Info, 01). It was the single largest disaster response undertaken by a single hospital in US history. Additionally, the hospital became a point of distribution for medical supplies, food, and water for disaster survivors.

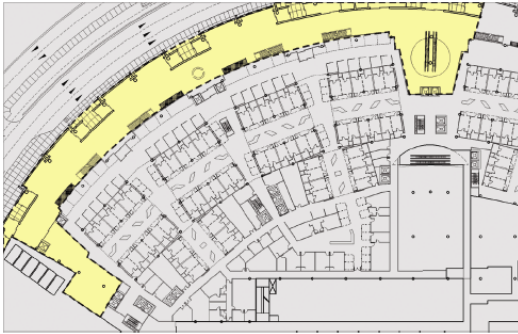
Although it would be difficult for any single facility to handle patient loads of that magnitude, several design considerations would have helped the facility operate more effectively during that mass casualty event. As patients poured into the facility from Ground Zero, there simply wasn't enough physical space to place them, resulting in



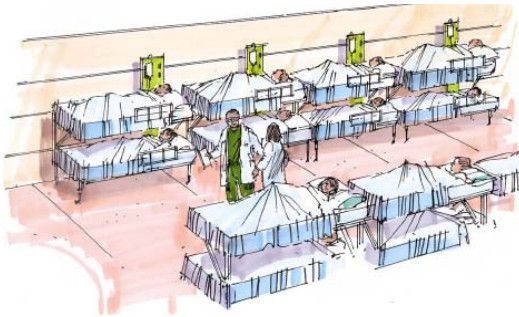
74. ER One: The All-risks Ready Emergency Department
2001 // HKS Architects

many being quickly stabilized and transported to other facilities. Non-essential interior spaces such as corridors and waiting areas were forced to become makeshift care areas, but were not configured or outfitted with the necessary equipment such as gas connections and medical supplies. While substantial disaster planning initiatives at the hospital were in place (as a result of the 1st terrorist attacks on the World Trade Center in 1991), the physical environment was just not configured to support them properly.

The ER One project in Washington DC was launched in 1999 to begin to investigate concepts, features and specifications for a “new type of all-risks ready emergency care facility, one optimized to manage the medical consequences of terrorism and emerging illness”(Washington Health Center, O1). In addition to its daily status as a fully functional trauma one emergency care facility, ER One was designed to accommodate volumetric surges associated with mass casualty events. The concept of ‘scalability’ drove the design of several key areas within the facility, including non-essential spaces, patient examination rooms, and exterior façade considerations.



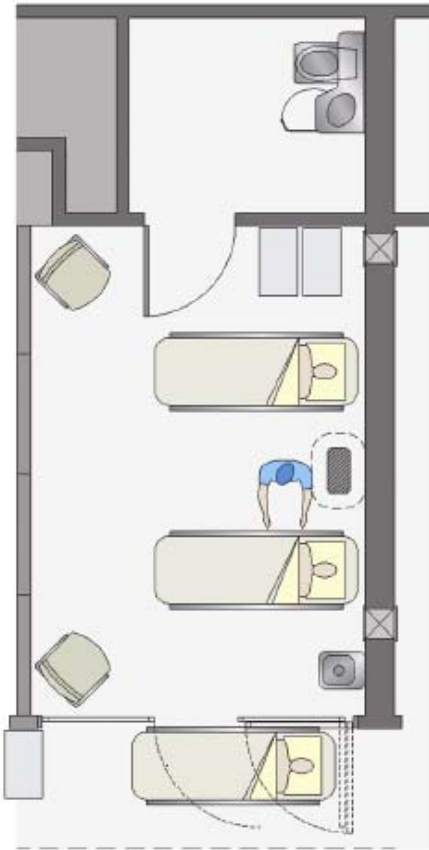
75. Public Space for Surge Use (Yellow)
2001 // HKS Architects



76. Public Space for Surge Capacity
2001 // HKS Architects

Additional bed capacity can be gained by recapturing non-essential spaces of opportunity such as hallways, auditoriums, atriums, conference rooms, administrative space, and waiting areas. As outlined by the design team, the three keys to making such a space usable for patient care are location of appropriate resources (water, med gas, power), use of appropriate materials which are sanitizable, and in close proximity of personnel ancillary support services such as restrooms (Pietrzak, 80). An additional level of flexibility was added to these areas by incorporating built-in beds into wall surfaces where applicable.

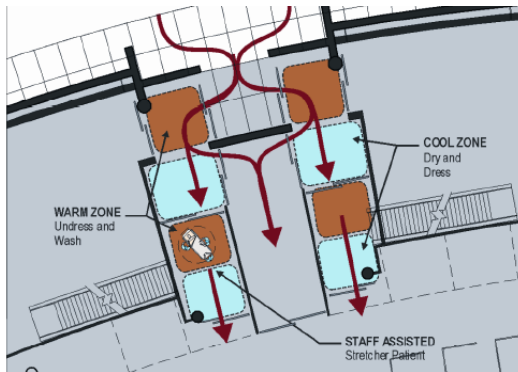
One important consideration that was not included in the design of the surge spaces was access to digital information modalities, a critical factor in the ability to communicate and locate assessment and treatment related data during surge events. For example, integrated digital wall surfaces in public areas could be utilized during daily conditions for entertainment and educational purposes, and provide a platform for staff to input, access, and transmit information when surge spaces are deployed. Additionally, staffing numbers could be instantaneously increased through by virtually



77. Expanded Treatment Room for Surge
2001 // HKS Architects

up-linking to doctors in remote locations hundreds of miles away, all via the same digital wall display.

Reconfigurable, universal treatment rooms in ER One provide caregivers with a level of flexibility not typically found in conventional emergency departments. The universal concept enables any room to be used for any function. If an increase in space is desired (as the 176 sq ft rooms can restrict certain types of activities and conditions), wall panels can be removed seamlessly. Through the use of self-contained gurneys and portable headwalls, treatment areas all have sufficient space, power, lighting and hookups to adapt quickly to a new configuration in minutes (Pietrzak, 79). The room can morph to accommodate surge capacity functions as well. Headwall provisions have been doubled to enable multiple patients to have access to those resources. Although not ideal, the verticality of the patient care space can be utilized for 'bunking' of beds to further increase occupancy. A vestibule area adjacent to a break-away entry wall adds yet another area to position a surge gurney. Another amenity (which is rarity in most emergency care environments) is the outboard toilet access off each room, further pushing the exam room closer to a typical inpatient space configuration.



78. Entrance Decontamination Zones
2001 // HKS Architects

As with the non-essential surge space design, inclusion of technological elements imbedded into the environment (complimenting the planned digital, handheld PDA charting system) would further extend its potentials by adding a level of digital flexibility and accessibility to the room. An integrated footwall display could be utilized to transmit large format patient information (such as ultrasounds, x-rays, etc) or uplink to telemedicine resources, distant family, or remote medical staff. The ceiling plane also offers an interesting surface to integrate interface technologies, as patients spend the majority of their time staring at it and it is out of harm's way.



79. Surge Decontamination
2001 // HKS Architects

The design of ER One's exterior façade elements also facilitates surge capabilities through regulation of the entry sequence, especially in the event of a biological attack when people may arrive contaminated. Decontamination capabilities are fully incorporated into each portal to ensure the level of sterility on the inside is maintained, complete with fresh water connections and drainage pipes (which lead to an independent storage tank). Additionally, entrance vestibules can be sectioned off through the use of non-obtrusive screening elements in order to alternate between



80. Portable Specialized Modular Medical
Consequence Management Units
2001 // HKS Architects

cool (dry and dress) and warm (undress and wash) zones. Each vestibule is also equipped with biometric scanning technologies in order to increase the level of control and awareness over human input into the facility (Pietrzak, 67). Furthermore, larger scale decontamination zones can also be activated in ground level ambulance parking areas, through the deployment of hazmat curtains and utilization of fresh water connections. Additionally, in cases when infectious agents are of such a concern they require isolated care areas (for SARS, the Ebola virus, etc) exterior docking areas have been provided to implement various modules which could be delivered via helicopter. The docking areas provide each module with power, water, and gas resources, as well as isolated drainage capacities (Pietrzak, 72).

An additional design consideration for the exterior façade that would strengthen the facility's ability to become a healthcare command center during surge events is to transform it into a digital information transmitter through the integration of technological elements. As discussed in the previous section, the ability for a façade to become a platform to inform, educate, and interact with the community can occur by fusing digital technologies within its architectural framework. Enabling the facility to



81. Loss of the Grid: Massive Power Outages in NYC's Times Square
2001 // Getty Images

transmit medical alerts, staff information, and potential threat warnings to the entire site and surrounding community would strengthen its ability to deliver care and maintain control during surge events. Additionally, smaller scale digital platforms available to the public via the exterior façade would enable them to have access to family members within the building without ever having to step foot in the facility. These same platforms could also be used as scanning modalities to prescreen potential patients in order to direct them to the proper area for treatment, filtering the 'worried well' from the 'seriously sick'.

Ability to Stay Online // During the terrorist attacks of September 11th and aftermath of Hurricane Katrina, the ability for local healthcare facilities to operate was crippled by their dependence on primary infrastructure elements (power and water) which were no longer available. Additionally, because of poor site selection, the capacity to take on patients at each respective emergency care environment was compromised or completely disabled. The capability for a facility to stay online and operational during mass casualty events is critical to its success, and vital to the ability of digitally integrated systems to make an impact on the delivery of care.



82. Downtown Hospital NYC: Urban Island Site

2007 // Google Maps



83. Devastating Floods Contaminated New Orleans's Water Supply and Destroy Power Infrastructure

2005 // net127.com

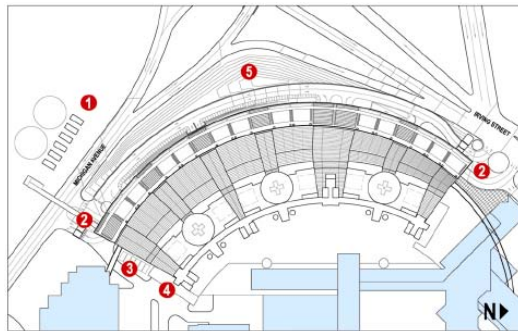
One of the leading contributors to the complications that the Downtown Hospital in Manhattan experienced handling volumetric surges during the terrorist attacks on September 11th was the loss of electricity, steam, gas, phone and computer services, and dangerously reduced water pressure [Lower Manhattan Info, 01]. The facility did not have any backup systems in place to take over once they were taken 'off the grid'. Another factor which compromised the effectiveness of the facility was its location on an urban island site. With no available adjacent areas for the expansion of hospital services, distribution activities had to occur in the same area where patients were entering the facility, mixing both populations and intensifying the chaotic conditions.

A similar situation occurred at New Orleans Memorial Hospital after Hurricane Katrina and its subsequent flooding destroyed the facility's power and water infrastructure. Many of the backup generators designed to keep the facility operational were located below the flood level, and were disabled as the waters initially swept in. A lack of water pressure rendered toilets unusable, filling the facility with a pungent smell of feces. Non-operable windows and loss of air conditioning resulted in the building becoming a



84. Patients are evacuated from New Orleans Memorial Hospital
2005 // bbcnewsameria.com

heat box. All available water sources were contaminated by floodwaters, a result of the household cleaners, sewage, and debris mixed into their depths. Since the hospital itself was located at a low point in the city, and the levee failure prevented waters from receding, the entire first floor was left underwater for several days (Quigley, 01). This effectively stranded the patients and staff who had weathered the storm, and prevented any new people from accessing the facility (which it could not handle anyway due to the loss of its primary infrastructure). The conditions became so dire inside the facility that staff decided to resort to euthanization of its most critical patients, denying the Hippocratic Oath of which they swore allegiance (BBC News America, 01).



85. ER One Exterior Staging Areas (Red)
2005 // HKS Architects

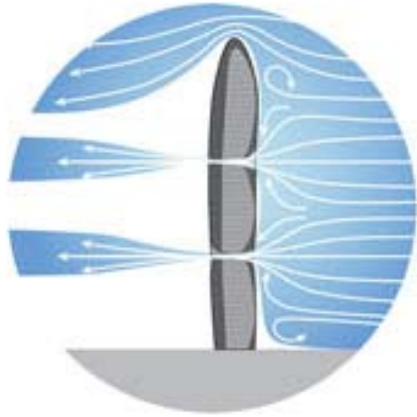
In both instances proper planning and design implementation of the facility did not accurately anticipate the demands and potential restrictions that could occur during a catastrophic disaster event. In planning for the ER One facility, a major site consideration was to place the facility in an area with adjacent, open areas which could be used for staging operations, contingency helipad space, quarantine modules, and decontamination services (Pietrzak, 86). The building's location near these established areas of opportunity enables it to further expand its services away from the building.



86. Pearl River Tower – Guangzhou, China
2007 // SOM Architects

By utilizing these areas, the facility is able to filter different populations into specific categories and separate them, minimizing mixing which degrades efficiency.

In order to remedy infrastructure failures during mass casualty events, technological solutions to make a healthcare facility self-sustaining can be integrated into the infrastructure of the building in the form of photovoltaic cells, wind turbines, and hydroelectric plants. An example of this form of integration is the Pearl River Tower in Guangzhou, China, which is designed in such harmony with its environment that it potentially produces as much energy as it consumes. The building's sculptural form guides wind through a pair of openings on its mechanical floors, pushing turbines that generate energy for the building's heating, ventilation and air conditioning systems. Additionally the openings provide a level of structural relief for the 303 meter tower by allowing wind to pass through the building instead of pressing against it. Abundant natural light, solar power and grey water retention also enhance the building's environmentally-friendly nature (World Architecture News, 01).



87. Wind Movement Diagram
Pearl River Tower – Guangzhou, China
2007 // SOM Architects

The selection and implementation of these technologies is dependent on climatic conditions, building orientation, and surrounding areas, all of which can be determined during the site analysis and selection phase. Incorporation of these sustainable technologies can enhance a healthcare facility's ability to remain operational for longer periods 'off the grid', improving its ability to respond during disaster events when civic infrastructure is prone to fail. Rainwater retention systems can also provide an isolated, uncontaminated water source, adding another layer of security to the operational solidity of the building. It is imperative for digital, environmentally integrated elements to remain operational; otherwise their positive impacts on the delivery of emergency care will be severely limited during mass casualty events.

Digital Interventions into the Emergency Care Environment

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.

The Throughput Process // Although each different emergency care facility has a specific operational model that they follow, analysis of several facilities yields a set of basic steps that are typically conducted in order to process, treat, and discharge patients. A description of each step will be given, identifying the architectural spaces involved and the current implementation of digital systems in those areas.



88. Reception Desk Positioned Next to Main Entry
2007 // Getty Images



89. Private Clustered Waiting Area:
Spartanburg Regional Healthcare System
Emergency Department
2006 // Ruthven

Step 01 _ Arrival // A person enters an emergency care facility, and the reception staff immediately identifies his/her needs, primarily placing them into a patient or visitor category. Once an individual has been identified as a potential patient, their name and birth date are recorded on the receptionist's personal computer and s/he is directed to an area to conduct patient registration with a triage nurse. Individuals identified as visitors are directed to waiting areas, or to the appropriate patient's exam room as appropriate.

The reception desk typically is placed directly in front of the main entry point, and is the most dominate architectural element in the triage area. Access to vertical circulation (if applicable) opens into this space as well, enabling the receptionist/triage nurse to monitor all people entering the environment. The inclusion of a separate private patient waiting area enables staff to limit the population in the public waiting area to only visitors. As illustrated by the Swedish Medical precedent study (figure xxx), clustered waiting areas are a way to further filter large crowds into smaller, intimate groupings. Connections to digital resources in the clusters would further strengthen



90. Patient Waiting and Registration Area:
Spartanburg Regional Healthcare System
Emergency Department
2006 // Ruthven

their ability to provide visitors with a sense of comfort and control, as well as positive distractions.

Step 02 _ Registration // Patient registration consists of a triage nurse assessing the patient's vital signs, medical history, and primary symptoms, which are then used to rate the patient's acuity level according to the National Triage Scale:

- Level 1 _ Immediate Resuscitation
- Level 2 _ Emergency
- Level 3 _ Urgent
- Level 4 _ Semi-urgent
- Level 5 _ Non-urgent

Triaging patients according to this scale ensures that the highest acuity patients are the first to receive medical assistance. The process typically occurs in a preliminary screening exam space adjacent to private waiting areas or the patient's exam room. A benefit to conducting patient registration in-room is the elimination of a superfluous step in the triaging process. However, in larger scale trauma centers utilization rates may prevent this from being feasible. All patient data is accessed and inputted via in-



91. Patient Exam Room: Spartanburg
Regional Healthcare System Emergency
Department
2006 // Ruthven

room personal computing stations by the triage nurse. In some instances, a wireless PDA can also be utilized to input basic patient information.

Step 03 _ Patient Placement // Once registration is complete, the triage staff assists the patient to the area of the ED that corresponds with their illness (unless they have already been placed in an exam room). Various departments (arranged by acuity) include, but are not limited to:

- Trauma (high acuity patients with severe, life-threatening conditions)
- Psychological (mentally unstable patients)
- Women's (care specifically related to female conditions)
- Heart (care geared towards the heart, arteries)
- Pediatrics (children's care)
- Orthopedics (focus on bone related illnesses)
- General Care (typical patient with mid range acuity level)
- Urgent Care (lower acuity patients, also referred to as 'fast track')

Once the patient has been placed accordingly, the triage nurse transfers preliminary chart information over to an emergency care nurse. The emergency care nurse rechecks the patient's vital signs and the primary assessment, using that data to



92. Medical Examination
2006 // Getty Images

accurately position the patient in line, based on necessity, to be seen by a doctor. Data is recorded either in the patient exam room, or at computer stations in the staff work core. Ideally, in-room registration would eliminate this step altogether.

Step 04 _ Medical Examination // The doctor is alerted of a new patient and travels to the corresponding patient exam room, in which he conducts a physical examination and collects a detailed medical history. The doctor then makes an important decision:

- Determine a diagnosis based on the information at hand, effectively skipping step 5
- Further dissect and examine the condition with a series of tests

At this point in the process, environmentally integrated digital interface elements could be utilized to access materials within the room. Otherwise, the doctor will have to rely on a paper chart he retrieved from the central nurse station, his PDA which displays data in low resolutions, or his memory which collected verbal information from the attending nurse. Additionally, wall interface elements could uplink to a virtual doctor when wait times reach an uncomfortable level.



93. Evaluation of Patient Condition via Imaging MRI Technology
2007 // Getty Images

Step 05 _ Evaluation // In order to evaluate the extent of a patient's condition more accurately, doctors will often order tests to be performed by imaging and laboratory resources. If required, patients are transported to the appropriate testing area, and then returned to their examination rooms when it is complete. Mobile imaging equipment may expedite this process by bringing the resources to the patient. Equipment alcoves should be located adjacent to patient care areas in order to nest the mobile units close by.



94. Diagnosis of Patient Condition
2007 // Getty Images

Step 06 _ Diagnosis // The doctor uses all available information, which was gathered during the examination and/or testing process, to determine a proper diagnosis. The observation and care of the patient is then turned over to the emergency care nurse, who is stationed in the staff work core.

A digital platform with which to display large format, high resolution images is desired at this point in the process in order to be able to visualize details from Ultrasound, R/F, MRI and CT scanners. Otherwise, the patient, doctor, nurse, and family members will



95. Verbal Explanation of Treatment Methods

2007 // Getty Images

all be forced to crowd around a miniature PDA screen or personal computer monitor [or nothing at all if those resources are not available].

Step 07 _ Treatment // Post-diagnosis, the emergency care nurse monitors the patient's vital signs, administering medication and nourishment when necessary. Depending on the progression of the patient's condition, the emergency care nurse takes on different roles:

- If conditions improve, the emergency care nurse prepares the patient for discharge by educating them about recovery methods & prevention techniques, and directs him/her to the appropriate area
- If conditions deteriorate, the emergency care nurse prepares the patient for transfer into an inpatient facility



96. Plethora of Technological Clutter: Spartanburg Regional Healthcare System Emergency Department

2006 // Ruthven

Patient vital monitors are one of the leading contributors to technological clutter in the caregiver environment. Whenever possible, integration of these elements into environmental surfaces such as the headwall would increase their visibility while minimizing their physical impact. The integrated digital platform would be ideal to assist a nurse in the education process before patient discharge. In cases when the



97. Patient Discharge
2007 // Getty Images

nurse cannot fully educate the patient and family due to time constraints, this wall interface could also be designed to perform the task on its own.

Step 08 _ Discharge/Transfer // In the discharge area, medication is received, insurance information is verified and any available payments are collected. As opposed to registration, discharge processes are desirably conducted in a separate area away from the patient exam room. That way, the room can be appropriately cleaned up, prepared, and turned over for the next patient. Expediting the clean-up and preparation of a room between patients is an important component in both the infection control and efficiency of the throughput process. By streamlining the environment and integrating available technology into environmental elements (think Zaha's Z. Island Kitchen), this process can occur in a more efficient and thorough manner. Additionally, when required, care for patients can be extended outside of the hospital walls and into to their residence through remote monitoring technologies. Where applicable, these digital elements can be located at off-site facilities independent of the primary care center.

The Digitally Integrated Emergency Care Environment // The importance of rapidly utilizing data for the effective delivery of care and optimization of throughput in the emergency department makes it an ideal healthcare typology for the integration of information technology. Deficient throughput methodologies have created several significant problems in emergency departments in the last decade, primarily stemming from antiquated charting systems (paper-based or mixed with IT elements) and inflexible facilities. An analysis of the basic throughput process highlights focus areas within the emergency care environment that are critical to its effectiveness, and therefore would benefit most from the integration of IT, including the entry triage area, patient exam room, and staff work core. IT integration into the selected focus areas within the architectural design, coupled with an updated, re-engineered care giving methodology, would create a safer, more efficient environment for the delivery of emergency care by improving the overall throughput process. Improvement to the throughput process would enhance the environment by remediating several other critical factors that degrade the quality of care in emergency departments, including overcrowding, staffing issues, and inability to accommodate volumetric surge events. It is imperative that reflection and consolidation of research materials occur, yielding a foundation for the architectural proposal in the form of a series of design principles.

DESIGN PRINCIPLES: LAYING THE FOUNDATION

If you have built castles in the air, your work need not be lost, that is where they should be. Now put the foundations under them.

Henry David Thoreau
US Transcendentalist Author (1874 - 1862)



98. Focus on Design Principles
2007 // Ruthven

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.

Building as Interface

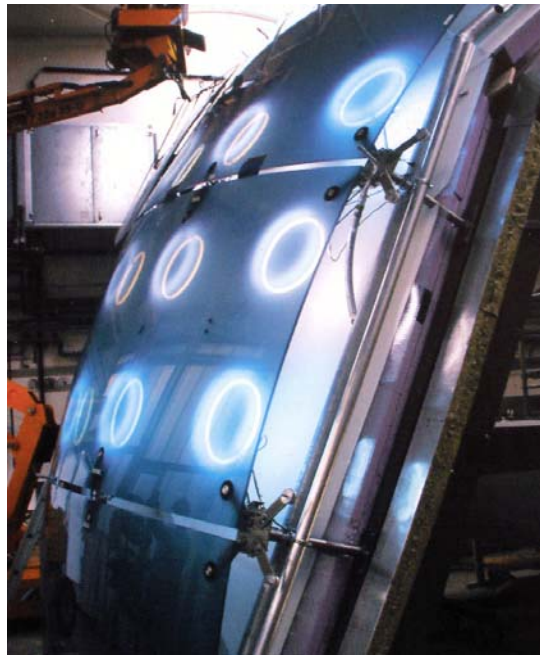


99. Building as Interface
2007 // Ruthven

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) to create technologically integrated building elements which create pervasive, highly accessible computing platforms for humans to input, access, and transmit information. This integration can be applied to both exterior and interior building elements, albeit in different ways and scales.



100. BIX Matrix Digital Building Skin
2005 // Architectural Design



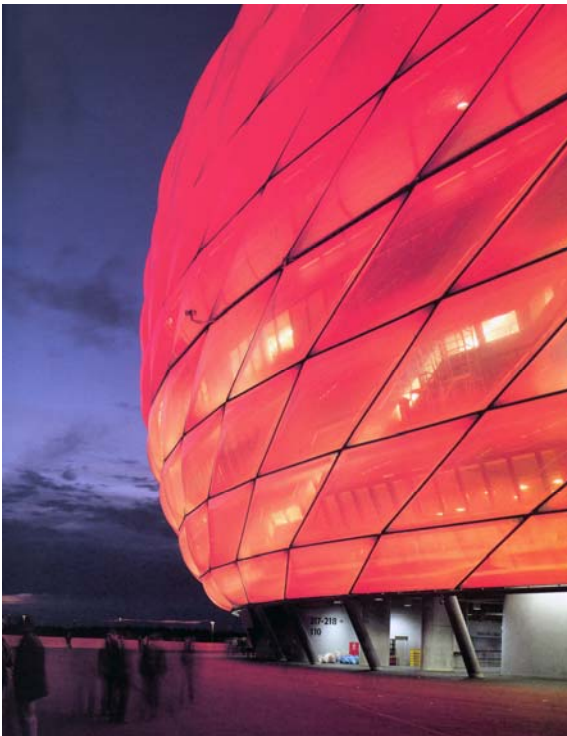
101. Section of BIX Matrix Digital Facade
2005 // Architectural Design

Exterior, Large Format Digital Skin Interfaces // 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. These platforms could also be utilized during mass casualty events, communicating information such as medical alerts and health warnings in large format to the public while creating an architectural landmark element in the community which would aid in wayfinding.

An example of a large format architectural interface is the BIX Matrix (which is an amalgamation of the words 'big' and pixel'), an interactive display integrated into the infrastructure of the exterior façade of the Kunsthaus Gallery in Graz, Austria. The display is meant to serve as a channel between the public and the facility, projecting dynamically updating images onto a predominant civic space 24 hours a day (Bullivant, 84). The building's semi-transparent acrylic building skin protects the intermediate electronic membrane from the elements. Each pixel within the overall interface is decidedly low tech, consisting of 930 independent circular fluorescent 40-watt light rings which are all controlled by a software program, allowing artists and curators to customize the display. The scale and iconography of the digital façade offer potential



102. Allianz Arena: Munich, Germany
2005 // Herzog + de Mueron

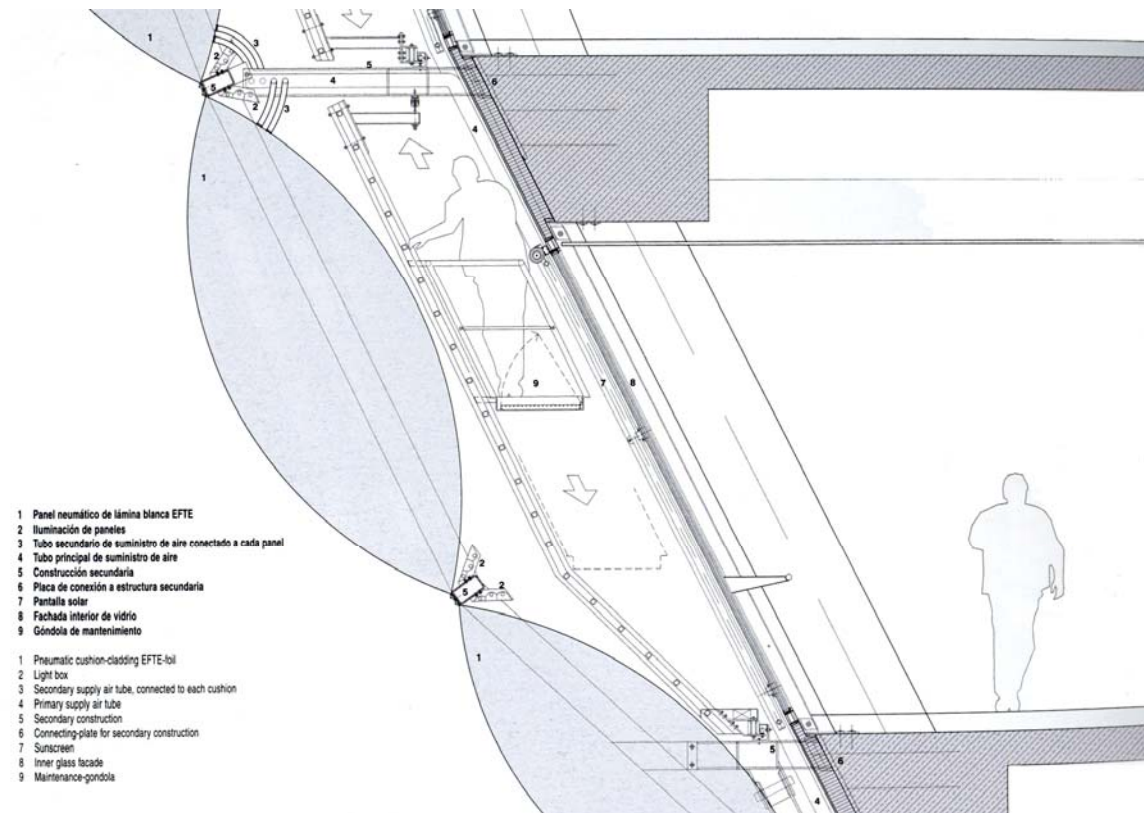


103. Close-up of Digital Façade – Allianz Arena
2005 // Herzog + de Mueron

applications to the emergency care setting. This type of large format interface could be utilized during mass casualty events to distribute information in the form of patterns and colors, such as a bright red cross symbol to denote that the facility remained operational and was prepared to take in disaster victims. Additionally, the iconography of such a display would cause it to become an urban landmark, serving as a wayfinding device for people during these events, as well as normative, day to day conditions.

Another precedent for a large format, architectural skin interface which has integrated digital components is Allianz Arena by Herzog and de Mueron. The exterior shell of the stadium is designed with a series of cells that can be illuminated from within by digitally controlled, color lighting elements. Since the stadium is shared by several different teams, the colored lighting is used to publically denote which one is playing in the stadium. Additionally, a multitude of patterns can be achieved by activating different combinations of lights, enabling users to customize the exterior to accommodate different types of events [Chevrier, 273]. A similar use of color could be used to signify interior conditions within an emergency care facility. For example, the color blue could indicate that the facility was experiencing a slight increase in traffic, and then transform to yellow when several buses full of wounded factory workers pull up

requiring an activation of surge planning and infrastructure. The simple use of color could enable the facility to have a rapid means to alert the general public, inform the surrounding neighborhood, and prepare the staff for dynamic shifts in the emergency care environment that are about to occur.



104. Section of Digital Façade – Allianz Arena, Germany
2005 // Herzog and de Mueron



105. Pervasive Computing via a Digital Wall Interface: *Minority Report*
2002 // 20th Century Fox

Digitally Integrated, Pervasive Surface Interfaces // According to the National Institute for Standards and Technology, pervasive computing is defined as numerous, highly accessible, often invisible computing devices which are frequently mobile or embedded in the environment, connected to an increasingly ubiquitous network structure [McCullough, 07]. Integration of interface technology into interior architectural surfaces in the healthcare environment can create these pervasive computing modalities, improving the efficiency and efficacy of care by providing a universal digital platform to input, access, and transmit medical information rapidly through a ubiquitous network.

The advantage this type of pervasive network has over traditional 'personal' computing modalities is that it is human-centered. There will no longer be a need to clutter the environment with devices we need to seek out to use. Instead, ubiquitous interfaces imbedded in the environment can bring the computing to us by providing a highly accessible, pervasive digital platform which can be simultaneously utilized by a multitude of users [McCullough 10]. Additionally, clutter and infection control issues associated with current implementation of information technology equipment are minimized by creating a streamlined, easily cleanable, single surface interface. The



106. Interactive Communications Experience (ICE) Digitally Integrated Interior Wall
2005 // Klein Dytham Architects

interface could be rapidly sanitized because it is one continuous surface, rather than the plethora of intricate, sensitive pieces found in a typical technological modality (such as the personal computer). These benefits have obvious translation to the healthcare environment, as they are typically overwhelmed with technological clutter and are highly sensitive settings which require an elevated level of cleanability.

The integration of pervasive computing interfaces into the healthcare environment can occur in many different building elements, including walls, ceilings, and floors. One example of an environmental interface element is the Interactive Communications Experience (ICE). A team of architects enlisted the help of an interface designer in order to conceive a design for ICE, in which a series of sensors were imbedded into a continuous wall/ceiling surface in order to detect human presence, reacting with a colored representation of their movement. At 'rest', the digitally enabled wall transmits information about stocks, with names swelling dynamically as the numbers update. In healthcare, a similar interface could be fused with a footwall in a patient room to become a platform to transmit medical data such as MRI images, electronic medical records, and educational resources. On the exterior of a healthcare facility, digital wall elements could be provided at the street level, enabling utilization of general health



107. ICE Being Utilized By Multiple Users

2005 // Klein Dytham Architects

information, discovery of available services, and access to the internet. The same exterior platform could also provide a virtual link to patients and missing person's reports at the street level during mass casualty events, enabling people to enter the facility without ever stepping foot into it.

Physical Threshold as Digital Scanner



108. Threshold as Digital Scanner
2007 // Ruthven

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, elevator doors, and vertical circulation access points).

Integration of identification technologies (such as biometrics and RFID scanners) into all physical threshold conditions within the healthcare environment would increase the staff's ability to maintain control and safety by identifying, tracking, and monitoring building inhabitants, equipment, and supplies. Additionally, the responses and access



109. Typical Threshold Scanner in the Retail Environment
2003 // vitag.com

levels of architecturally integrated pervasive computing interfaces (discussed in the previous design principle) could be controlled and customized to respond to different users (nurses, doctors, patients, etc.) in an appropriate, secure and interactive manner. For example, as a doctor crosses through a digital door threshold scanner into a patient's room, his presence triggers the system to turn down the television set and brings up his/her name and picture on the digital footwall interface for reference. An additional image of the doctor is projected on a digital wall surface adjacent to the room, informing other staff members of his/her presence in the room. The scanner also unlocks a series of voice commands that the doctor can use to control lighting, temperature, sound levels in the space. Automation of tasks (such as the display of identification upon entry into a space on an appropriate architectural interface) can aid staff by minimizing their task load. Additionally, technological integration into thresholds can mask obtrusive systems, such as the bulky RFID tag scanners employed in most retail settings, limiting the sensation of loss of privacy and amount of physical clutter which can make the healthcare setting feel more institutional.

Examples of digital threshold scanner systems have been instituted in several different settings, including airports, banks, and government buildings, where high levels of



110. High Security Revolving Door Systems with Integrated Identification Technology

2002 // airport-int.com

security and desire for discretion exist. At the Narita Airport in Japan (discussed in detail in the previous section), has installed several high security revolving door systems which have biometric scanning and bi-focus camera technologies integrated into the ceiling. If people who pose known threats are identified outside of the airport and attempt to travel through the entry threshold, the door system can lock down into two configurations, containing the suspects safely within its constructs.



111. ER One Project: Biometric Security Station Vestibule

2003 // HKS Architects

The ER One 'All Risks Ready' Institute project in Washington DC uses similar design considerations at major threshold conditions to increase security considerations. Biometric identification scanners are outfitted into each door threshold to ensure each person is scanned upon entry or exit to the facility. If an individual has presented false credentials and poses a security threat, a lockdown condition can be initiated by an adjacent staff member or the digital system itself, isolating the potential risk in the contained vestibule. This point also acts as a distribution center for an RFID security band which allows the facility to track all of its inhabitants no matter where they are in the building. Equipment and supplies are tracked in a similar manner, with tagging stations located at loading dock thresholds on the backside of the building. As an



112. Responsive Lighted Floor Panels Interacting with Inhabitants - ADA
2001 // Architectural Design

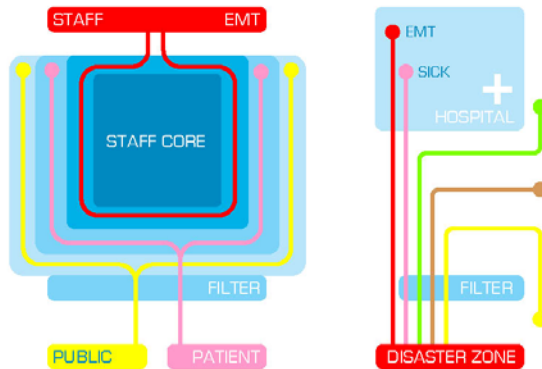


113. Digital Sensors Integrated into Lighted Floor Panel - ADA
2001 // Architectural Design

added benefit, medical errors associated with misidentification can be eliminated through usage of these tracking technologies (Pietrzak, 202).

ADA the Intelligent Room (named for computer science pioneer Lady Ada Lovelace) is a digitally integrated, artificial intelligence environment which performs in the same manner as a human central nervous system, with digital threshold conditions serving as 'her' eyes. ADA uses biometric scanning and sensor technology at different control points to detect and decipher different users within its constructs, responding with varied modes of interaction including audio and visual cues. 'She' incorporates four basic behavioral functions, including tracking, identifying, grouping, and playing in order to interact with people in a more 'humanistic' manner, all of which are triggered by sensors imbedded into wall, floor, and ceiling surfaces. While the integration of these same technologies in the ER One example was purely for security and control reasons, this precedent study illustrates how they could be used in a comforting, playfully interactive manner to improve the quality of the healing environment (Bullivant, 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 an interactive positive distraction.

Organize Facility into Layers of Penetration



114. The Layers of Penetration – Daily vs. Surge Operations

2007 // Ruthven

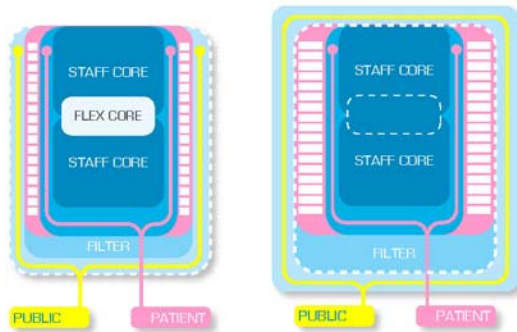
The three main categorizations of people who exist within the emergency care environment include public, patient, and staff typologies. In order to further improve security, the facility needs to be designed into layers of penetration, regulating access to only those groups who meet proper security clearances 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.

The Swedish Medical Issaquah Freestanding Emergency Department in Seattle Washington was designed with a similar organizational model, filtering public, patients, and staff into three distinct layers of penetration. The facility's circulation is organized to separate visitors and patients from the staff work core, minimizing distractions and contamination in that area. Public circulation is distributed along the exterior of the building, coupling it with decentralized, clustered waiting spaces. In order to provide access to patient care spaces for staff and visitors (since they are located at the center of both areas), each room contains a set of doors on each wall. The organizational model at Swedish has led to an increase in customer and staff satisfaction levels, and reduction in security issues in the ED (Faulkner, 01).



115. The Layers of Penetration – Swedish Medical Freestanding ED
2007 // Ruthven

Building as Sponge

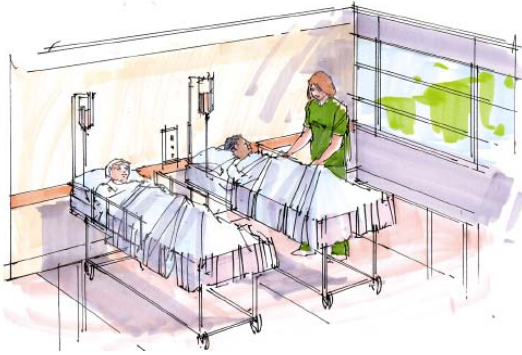


116. Building as Sponge

2007 // Ruthven

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.

If the facility and its systems remain static during surge events, the quality and effectiveness of its care delivery will be severely hindered. As experienced during the September 11th terrorist attacks at Downtown Hospital in Manhattan, a thorough preparedness plan is only as strong as the facility it is being implemented in. The unpredictable surge of patients they experienced (350 in the first 2 hours)



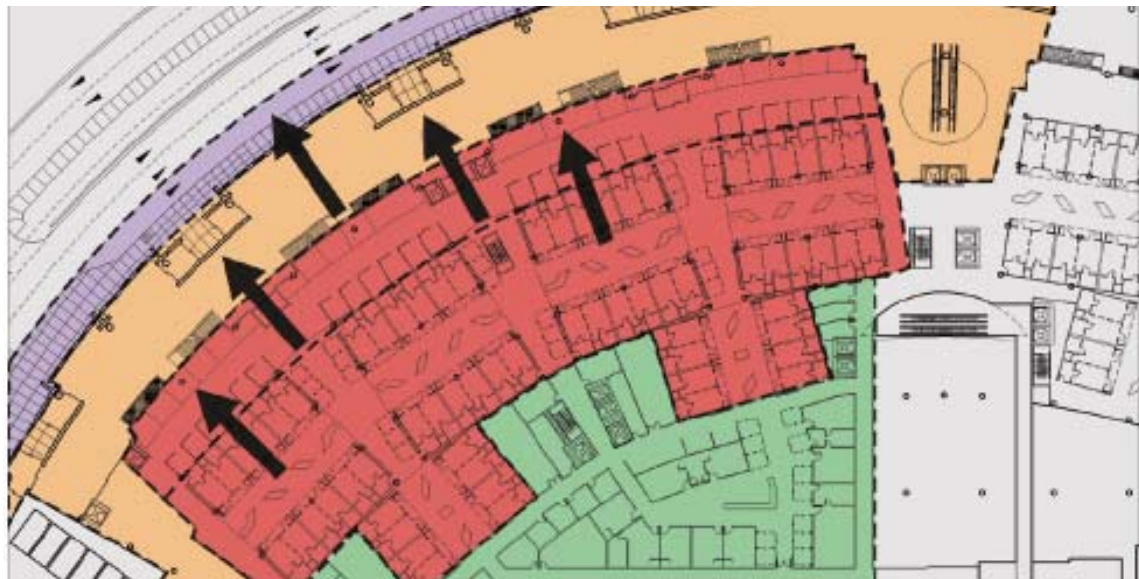
117. Surge Beds Deployed In a Corridor
2001 // HKS Architects

overwhelmed their system, and severely degraded the level of effectiveness of their emergency care services. However, overdesigning spaces to solve this problem (such as increasing a single occupancy patient exam room to 450 sq ft to accommodate more beds) is unfeasible because it will lower efficiency during the majority of time when the building is not in 'surge mode' by increasing the size of the unit footprint dramatically. Additionally, the initial cost of an overdesigned facility will be much higher, again due to increase in square footage.

A way to solve this issue is to utilize non-critical spaces for surge expansion during mass casualty events, including visitor waiting areas, atriums, and corridors. Additionally, critical spaces can be designed to adapt to accommodate and increase in patient and staff activity, including examination rooms and decontamination areas. Together, these concepts constitute the 'scalability' of a facility.

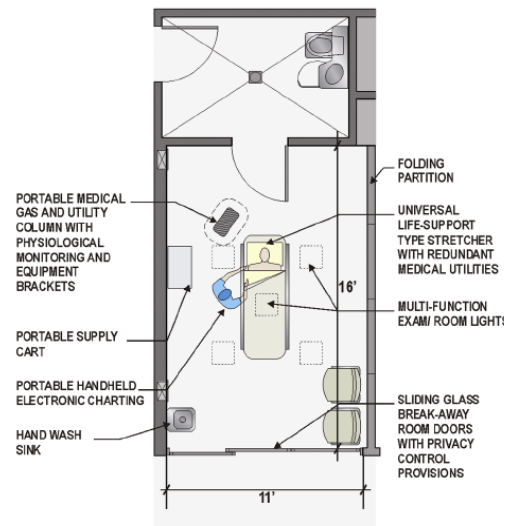
In the ER One Project, the concept of 'scalability' drove the design of several key areas within the facility, including non-essential spaces, patient examination rooms, and exterior façade considerations. Additional bed capacity was gained by adapting non-essential spaces of opportunity such as hallways, auditoriums, atriums, conference

rooms, administrative space, and waiting areas. Three key components to making such spaces usable for patient care were incorporated into the design of those areas. They include the adjacency of primary resources (water, med gas, and power), use of a sanitizable materials palette, and collocation with ancillary support services such as restrooms (Pietrzak, 80). Where applicable, an additional level of flexibility was added to these areas by incorporating built-in beds into wall surfaces.

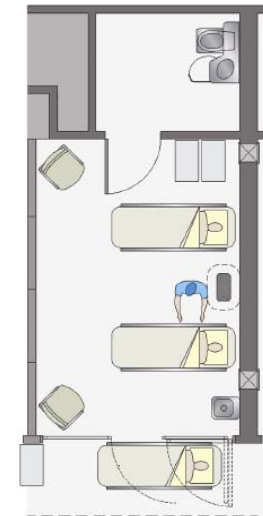


118. Non-essential Expansion Zones (Orange), and Critical Space Adaptations (Red)
2001 // HKS Architects

The Proposal for ER One also demonstrates that reconfigurable, universal treatment rooms can provide caregivers with a level of flexibility to increase their patient occupancy loads. An increase in space can be facilitated through the removal of modular wall panels. Headwall components designed for extra capacity and utilization can ensure that each additional patient within the care area will have access to proper treatment essentials. A vestibule area adjacent to a break-away entry wall adds yet another area to position a surge gurney. A rarity in typical emergency care environments, the outboard toilet access off each room enables patient movement to occur mainly within the room, and better accommodates the entire unit when occupancy is increased (Pietrzak, 80).

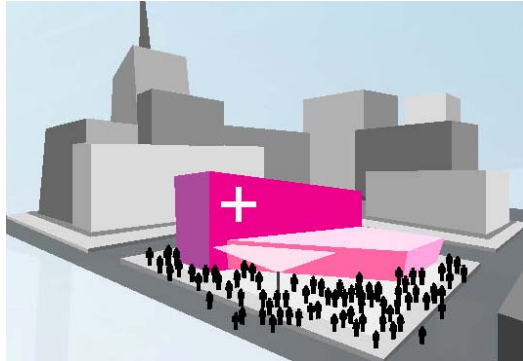


119. Typical Patient Exam Room Configuration
2001 // HKS Architects

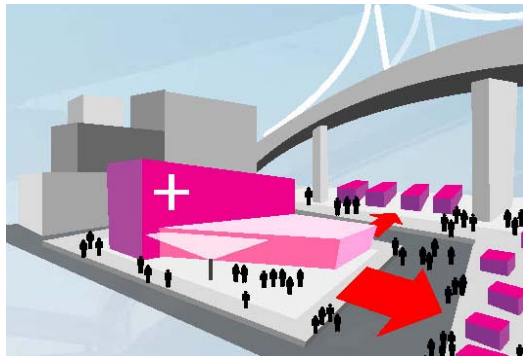


120. Expanded Surge Treatment Room
2001 // HKS Architects

Appropriate Existing Infrastructure



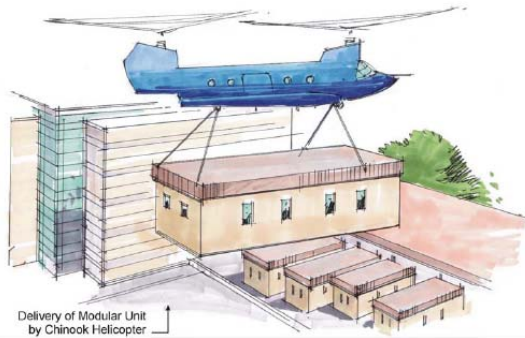
121. Urban Island ED Overrun and Without Any Adjacent Room to Expand
2007 // Ruthven



122. Appropriated Shelter Expands Services 2007 // Ruthven

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



123. ER One - Modular Units Deployed in an Adjacent Parking Area
2001 // HKS Architects

decontamination process, and storage space for stockpiling and dispensing of supplies, food, and water.

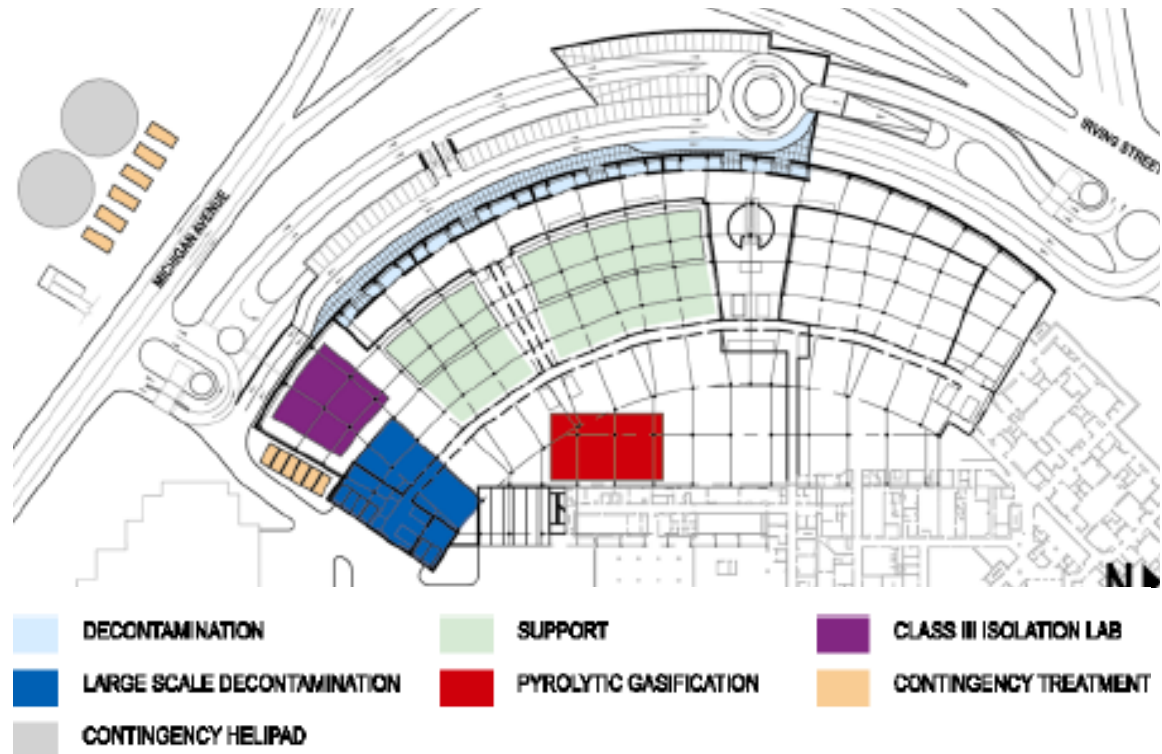
During mass casualty events, various types of people (the walking wounded, scared, homeless, malnourished, disillusioned, and foragers) all descend on emergency care facilities in hopes of receiving aid. Dispersing services in appropriated surrounding areas to assist the 'walking well' will limit the amount of people who descend directly into the care facility, allowing it to focus its operations on only those who require medical assistance (the 'really sick').



124. ER One - Contingency Helipad Space in Surrounding Green Spaces
2005 // HKS Architects

In planning for the ER One facility, the placement of the facility was guided by the need to have adjacent, open areas which could be used for staging operations, contingency helipad space, quarantine modules, and decontamination services (Pietrzak, 86). The building's location near these established areas of opportunity (adjacent green spaces and parking surfaces in this instance) enables it to further expand its services away from the building. By utilizing surrounding areas of opportunity, the facility is able to filter different populations into specific categories and separate them, minimizing mixing of services which can degrade efficiency. The building also made use of its own

infrastructure through the adaptation of parking areas below grade into large scale decontamination chambers. This added degree of expansion was a preliminary concern during the design of the facility, and was a driver during the site selection process. Justification for building placement can be reinforced by collocating it with infrastructure elements (bridge overpass, established green spaces, parking garages, fresh water supply) that can be appropriated to accommodate expansion.



125. Ground Level Expansion of Services into Existing Infrastructure – ER One

2001 // HKS Architects

A Fundamental Basis for Design

The established set of principles serve as a fundamental basis for the architectural design by ensuring that the integration of information technology into the environmental framework of the emergency department will work to improve its ability to effectively and sufficiently deliver care during both typical daily operations and mass casualty surge situations. Conceptualizing the building as an interface allows it to create digital connections to the community at large, as well as improve the efficiency and efficacy of care internally by providing pervasive, environmental computing platforms to access information systems. The system's ability respond in an effective, safe, and appropriate manner can be regulated by integrating identification scanners into threshold conditions within the environment. Threshold scanners can define environmental constructs, which once penetrated enable users to become keys that are able to unlock different digital layers and prompt appropriate responses from the integrated technologies. An additional consideration in order to maintain safety, maximize workability, and ensure a level of sterility in sensitive environments, is that the facility needs to be designed into nested layers of penetration, limiting access to only those inhabitants who meet sufficient security clearances. In order to accommodate

increased patient volumes by increasing the layers of penetration, the building and its infrastructure need to act like a sponge, expanding and contracting in an effort to reorganize and configure itself to accommodate conditions such as mass casualty surge events. In addition to increasing its on-site capacity, the facility should be collocated with adjacent, existing infrastructure elements, which can be appropriated for usage during mass casualty events. These associated spaces help strengthen its effectiveness by establishing a point of distribution for multiple forms of disaster relief beyond purely healthcare services. Holistically, the design principles also serve as determining factors for both the programmatic and site criteria for the final proposal.

A PROGRAM OF PREPARATION

The functional program defines the rooms or spaces by how they will support the operations of the department or what function each will serve.

John Huddy, AIA

Author of "Emergency Department Design: A Practical Guide to Planning for the Future" (1962 -)



126. Focus on Program
2007 // Ruthven

The program was developed as a freestanding emergency department in which there is no connection to an existing facility in order to minimize complicating and distracting design issues and constraints from diluting the stated focus of the thesis exploration and project. Although rare in the US, freestanding emergency care facilities are a viable option for expanding healthcare provider's coverage, capturing areas with growing populations and improving their network's ability to respond effectively during mass casualty events. A series of potential mass casualty event scenarios were developed in order to prepare conceptual simulations for the facility design to test possible responses, as well as derive programmatic elements. This section contains a general space list for a freestanding emergency care facility, organized into the layers of penetration (public, patient, & staff) and including net/gross square footage estimates. Additionally, a surge space list is included, complete with descriptions of which spaces adapt and expand. Finally, an analysis of traditional setups for the three

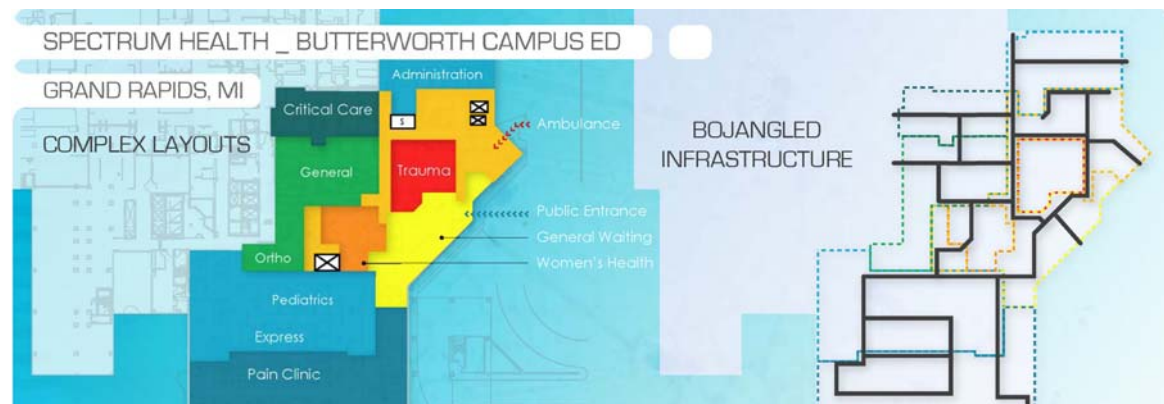
focus areas (entry triage, patient exam room, and staff work core) within the emergency care environment outlines important programmatic design considerations, as well as opportunities for those spaces.

Freestanding Medical Emergency Departments

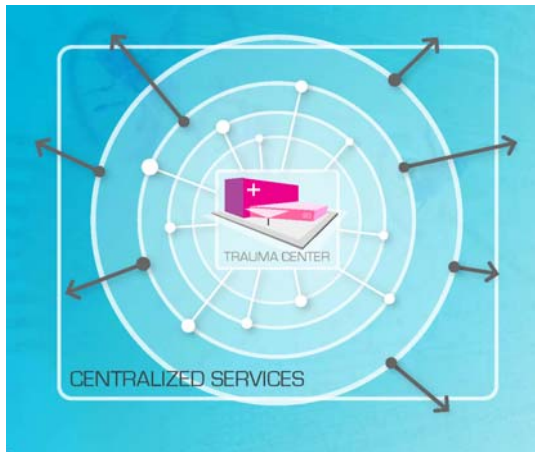
Typically, emergency departments are attached to larger, comprehensive healthcare facilities, acting as the primary point of entry for approximately half of all admittances into hospital inpatient facilities. However, this type of emergency department design or renovation introduces an abundance of non-pertinent issues in to 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.

The Urban Mega-ED // The emergency department serves as the front door to major urban trauma centers, with approximately 16 million patients entering through its doors each year (roughly 44 percent of all hospital stays or 55 percent of hospital stays excluding pregnancy and childbirth) [American Hospital Association, 03]. Large scale emergency departments usually operate as a hospital within a hospital, being self

sufficient through the inclusion of critical infrastructure elements (such as imaging and laboratory components) within its walls. However, renovating or adding onto an existing facility involves addressing a wide range of constraints and concerns not directly pertinent to the thesis project. Non-pertinent issues associated with renovations and additions include utilizing existing infrastructure which could complicate or prevent technological integration from reaching its full potential, extensive phasing considerations in order to maintain operations, stringent site restrictions that can cause a lack of control over placement, orientation, and design of the facility, and adherence to conditions (such as circulatory paths, column grids, and entry points) in existing, connected facilities. An analysis of Spectrum Healthcare System's Butterworth Campus emergency department illustrates some of the typical complex, design burdens found in the typical expansion/renovation project.



127. Complex Existing Layouts and Infrastructure: Spectrum Health Butterworth Campus ED
2007 // Ruthven

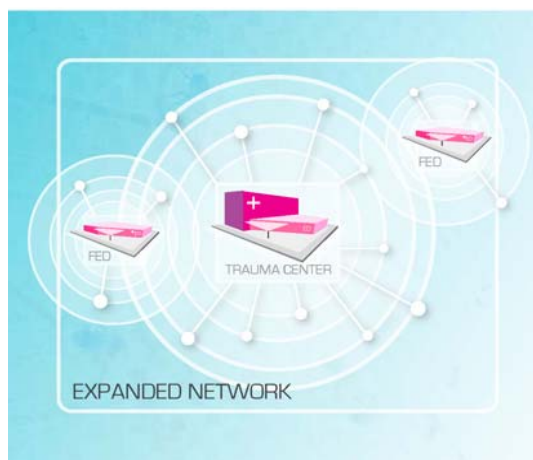


128. Loss of Periphery Area Revenue and Burden on Centralized Services

2007 // Ruthven

Deconstructing the Urban Mega-ED // 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 existing coverage areas to capture revenue in growing areas of the community, providing more cost effective care to medically insured populations, 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 by spreading out the coverage area by creating multiple access points in case other facilities are disabled [Lott, 02].

Typically, large emergency departments operate within dense population areas and represent the primary access point of care for local urban inhabitants and also the larger surrounding region. As a result of the large coverage area, these urban trauma centers are inundated with patients 24 hours a day from a vast array of locations, with acuities ranging from minor colds to gunshot wounds. The filtration process begins when patients enter the door (unless they are admitted by ambulance), and they are triaged according to the nature and severity of their illness. In order to process



129. Comprehensive Health Network Captures Growth and Increase Preparedness

2007 // Ruthven

patients of lower acuity so that focus and attention can be directed to life-threatening conditions, the majority of urban trauma centers have established fast-track care areas. Despite minor initial improvements in efficiency, the fast-track areas are simply an inadequate band-aid applied to a system that has severe, internal wounds (Lott, 02). In order to relieve the tremendous volumetric burden placed on urban trauma center and alleviate many of the problems that ail its emergency department, the filtration process needs to begin before patients arrive at these facilities.

One way this can be achieved is through the implementation of freestanding emergency facilities located within the service network around existing urban trauma centers. A comprehensive system of freestanding 'satellite' care buildings (freestanding EDs, urgent care centers, and clinics) could essentially become a decentralized triage for the trauma center, transferring only those patients whose acuities require the specialized technology and services offered by the large scale healthcare center. Establishment of such a network would relieve volumetric burdens on the existing facilities, enabling caregivers to renovate their emergency department with less disruption of overall service. Additionally, new patient populations can be



130. WakeMed Freestanding Emergency Department, Raleigh NC

2006 // wakemed.org

captured in expanding population areas, using regional growth statistics and demographical information as the drivers for the placement and size of the satellite care services [Karlsberger Architects, 03]. Disaster response preparedness is also improved through the expansion of services rather than consolidation into a singular, centralized area which would cripple an entire region was it to fail.

A Brief History of Freestanding EDs // Freestanding emergency departments have been in existence since the early 1960's, but still remain relatively sparse in the United States. These facilities are distinctive from traditional hospitals as they do not provide inpatient services, but they typically provide similar treatment options (minus trauma in some cases) as conventional EDs [Shady Grove Adventist Emergency Center, 01]. As of 2006, successful examples of these facilities can be found in several states, including Texas, North Carolina (pictured), and Florida. Many of these facilities are "full-service EDs with surgical and observation capacity, but most opt to transfer all surgical patients to the base hospital" [Karlsberger Architects, 03]. Since emergency department patients are considered 'outpatients' (as determined by the Centers for Medicare and Medicaid Services), it is common to see freestanding EDs co-located



131. Swedish Medical Issaquah
Freestanding ED, Seattle WA
2006 // Callison Architects

with other ancillary outpatient facilities, including clinics, imaging suites, ambulatory surgery centers, and physicians offices [Karlsberger Architects, 04].

Recently, freestanding emergency departments have become more popular as healthcare providers attempt to expand their market share, capturing growing suburban areas with affluent middle class, well-insured patient populations. A successful example of implementation of a supporting freestanding emergency care facility is the Swedish Medical Center in Seattle, Washington. The facility was built because the main trauma center in downtown Seattle was unable to accommodate the large amounts of new patients they were receiving from rapidly developing suburban areas outside of the city. Additionally, patient satisfaction rates were down because of the long travel distances they had to endure to receive care [Faulkner, 01]. In an effort to capture the growing market of well-insured patients (derived from market analysis), as well as make services more convenient and accessible, Swedish contracted Callison Architects to design a freestanding emergency department for the eastern suburbs of Issaquah, WA. The success of the facility has been unprecedented, even surprising Swedish Medical executives that had initially cringed at the thought of



132. Swedish Medical Issaquah
Freestanding ED, Seattle WA Floor Plans
2006 // Callison Architects

another emergency care facility to have to support (Faulkner, 01). Several important features define the new facility, including a 'no wait' policy, decentralized visitor waiting areas on the exterior, shared daylight to patient exam spaces, and a staff-only work core. Since the 55,000 square foot ED is not attached to a larger hospital, it has all of the vital equipment and services (such as imaging and laboratory) available on-site for patients.

Potential Scenarios and their Programmatic Response



133. The Highly Touted Homeland Security Advisory System

2007 // Department of Homeland Security

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.

The color coding system was based on the Department of Homeland Security's Advisory System in order to connect it with nationally recognized protocol. Each scenario consists of an operational level (defined by a color), expected patient loads per hour, anticipated events, and the facility's response. The base number of beds was derived from the Swedish Medical Issaquah Freestanding Emergency Department in Seattle, Washington by Callison Architects.

Operational Level	Patients / Hour	Anticipated Events	Facility Response
Level 1 _ Daily Operations	≤10	Normal Operations	16 Patient Care Spaces
Level 2 _ Increased	11-15	Flu Season Anthrax Hoax Binge Drinking Party	16 Patient Care Spaces Registration + Overflow Patient Waiting
Level 3 _ Elevated	15-20	Vehicular Pileup Group Drug Overdose Apartment Fire	24 Patient Care Spaces +8 Beds
Level 4 _ Critical	21-30	Mass Transit Accident School Assault Hostage Situation Plant Explosion	32 Patient Care Spaces +16 Beds
Level 5 - Surge Capacity	≥31	Hurricane Flood Earthquake Terrorist Attack (Explosions, toxic gas attacks, radiological elements) Pandemics	40 Patient Care Spaces +24 Beds Exterior Deployment of Low Acuity Patient Care +60 Beds Extend Traige Filtration Area to Site Periphery

The Base Program with Surge Modifications // This section contains a general space list for the freestanding emergency care facility, organized into the layers of penetration (public, patient, & staff) including net/gross square footage estimates for community services, emergency department, outpatient imaging, and life support structure (which provides a source of power and fresh water to the facility). The program is based off a similar model used for Callison Architect's Swedish Medical Freestanding Emergency Department.

The program is broken down by area (community services, emergency department, outpatient imaging, and life support structure) into a series of spaces. In some instances, spaces are modified and adapted during mass casualty surge events to accommodate increased usage. These changes are highlighted in the program and attached to the scenario level in which they occur, denoted with the appropriate color. For example, if a program component remains the same during all conditions, then it is contained all on one line in the table. If the space adapts (like the visitor waiting areas for example) to changing conditions during different levels of activity, the entry is broken down by level, with programmatic responses and square footage estimates listed to the right.

Program Summary			
Service Line	NSF	Net to Gross	Total GSF
Community Services	2075	X 1.45	3010
Emergency Department	14990	X 1.45	21736
Outpatient Imaging Services	6880	X 1.45	9976
Life Support Functions	3600	X 1.45	5220
Total GSF	27545		39942

Public Areas (Community)	Level					QTY	Net Sq Ft	Total	Comments (2075)
Bus Stop	1	2	3	4	5	1	75	75	Integrated digital kiosk element
Community Center	1	2	3	4	5	1	250	250	Variable space TBD by community needs
Delicatessen	1	2	3	4	5	1	400	400	Food services for entire facility
Public Parking	1	2	3	4	5	1	750	750	Total parking spots required = 30 on-street parking can be utilized. Include connections to med gas, power, water for surge bed deployment
Digital Community Access Wall	1	2	3	4	5	1	200	200	Locate adjacent to main circulation areas
Pharmacy	1	2	3	4	5	1	400	400	Locate on street level to enable access from pedestrians, as well as building inhabitants

Public Spaces (Emergency Department)	Level					QTY	Net Sq Ft	Total	Comments (920)
Emergency/Outpatient Services Entrance Lobby	1	2	3	4	5	1	600	600	Combine both entry points in order to maintain the area as a control point for people intake. All vertical circulation and main entrances should open into this area
Reception/Security Station	1	2	3	4	5	1	200	200	Combine into one singular station with integrated IT elements and kiosk registration areas
	1	2	3	4	5				Provide mobile components to move reception areas outside of the facility to regulate patient intake
Wheelchair/Stretcher Storage	1	2	3	4	5	1	120	120	Adjacent to reception area and should contain mobile reception equipment

Public Spaces (Emergency Department)	Level					QTY	Net Sq Ft	Total	Comments (3500)
Entry Vestibule	1	2	3	4	5	2	120	240	7' minimum vestibule or revolving door options equipped with integrated identification scanners
Quiet Room	1	2	3	4	5	2	100	200	To be provided near trauma and observation areas within the unit
Public Toilets	1	2	3	4	5	4	150	600	Disperse in even increments through dept
	1	2	3	4	5	1	400	400	Increase size can be considered to accommodate adjacent surge beds
Discharge Exit Lobby	1	2	3	4	5	1	400	400	Discharge services to be collocated with main entry/exit
Discharge Station	1	2	3	4	5	3	100	300	Collocate with main entry/exit
	1	2	3	4	5				Adapt discharge to become overflow registration area as needed
Visitor Waiting Areas	1	2	3	4	5	32	30	960	Clustered along the exterior of the building adjacent to patient care areas, arranged into 3 distinct modules
	1	2	3	4	5			320 per module	Activate 1 st , 2 nd , 3 rd surge module of patient gurneys [+8/module], provide gas, power, and water outlets along exterior wall
Children Play Areas	1	2	3	4	5	2	100	200	Provide in corners adjacent to visitor waiting areas
	1	2	3	4	5				Utilize as clutter corners for the placement of waiting area furniture
Café	1	2	3	4	5	1	200	200	Place at halfway point in emergency care unit as a break condition
	1	2	3	4	5				Utilize as clutter corner for the placement of waiting area furniture

Patient Care Spaces (Emergency Department)	Level					QTY	Net Sq Ft	Total	Comments (4480)
Patient Examination Room (Totals)						16	-	3840	Arranged from low-high acuity. Provide provisions for double occupancy (med gas, power, water). Subdivide room into wet + dry work zones, as well as a family area. Rooms should be same handed, universal spaces improve performance + safety
- Fast Track	1	2	3	4	5	4	240	960	Locate close to main entry to expedite care process
- General Care	1	2	3	4	5	4	240	960	Locate close to main entry to expedite care process
- Orthopedics	1	2	3	4	5	2	240	480	Provide ample counter space for casting activities (4' x 1')
- Pediatrics	1	2	3	4	5	2	240	480	Place in as isolated an area as available to minimize visibility to more traumatic areas
- OBGYN	1	2	3	4	5	2	240	480	Provide bathroom in at least one of the rooms
- Observation	1	2	3	4	5	2	240	480	Provide bathrooms in both rooms
- Trauma	1	2	3	4	5	2	480	480	Combine into one, large bay space with removable center partition
Patient Toilet	1	2	3	4	5	8	30	240	Disperse throughout unit (1 bathroom per 4 patient exam rooms)
Patient Waiting Area	1	2	3	4	5	1	200	200	Locate adjacent to entry triage area
Overflow Registration Room	1	2	3	4	5	1	200	200	Locate adjacent to entry triage area

Staff Work Areas (Emergency Department)	Level					QTY	Net Sq Ft	Total	Comments (2180)
Ambulance Service Areas						1	-	1480	Ambulance service entry doubles as staff entry point from parking areas
Ambulance/Staff Entry	1	2	3	4	5	1	400	400	Collocate with trauma, observation, and decontamination areas
Ambulance Vestibule	1	2	3	4	5	1	200	200	7' minimum vestibule equipped with integrated identification scanners
Decontamination Showers	1	2	3	4	5	1	200	200	Locate adjacent to ambulance entry
	1	2	3	4	5	1	300	300	Expand services to exterior areas adjacent to showers for mass decontamination. Include overhangs or coverings to shield exterior areas.
EMT/Hazard Response Storage	1	2	3	4	5	1	140	140	
Trauma Bay Support	1	2	3	4	5	2	60	120	
Deceased Patient Viewing Area	1	2	3	4	5	1	120	120	
Offices						7	-	700	Locate close to, but not within, staff core
- Physician Offices	1	2	3	4	5	2	100	200	Provide bathrooms in both rooms
- Additional Staff Offices	1	2	3	4	5	4	100	400	Quality Assurance Office, Educational Services, Charge Nurse Office, EMT
- Security Office	1	2	3	4	5	1	100	100	Locate near ambulance and trauma rooms

Staff Work Areas (Emergency Department)	Level					QTY	Net Sq Ft	Total	Comments [2370]
Core Station						1	-	1050	All functions performed in the staff core are to be integrated into flexible, integrated digital workstations
- Nurse Work Area	1	2	3	4	5	1	500	500	Combine with physician working areas to promote equality and interaction, as well as minimize footprint
- Physician Work Area	1	2	3	4	5	1	250	250	Combine with nurse working areas to promote equality and interaction, as well as minimize footprint
- Nutrition Area	1	2	3	4	5	1	150	150	Patient exam room storage of nourishment can also be considered to minimize core space
- Medication Area	1	2	3	4	5	1	150	150	Provide access to digital resources within surface of meds area to enable charting during preparation
Trash Room	1	2	3	4	5	1	100	100	
Housekeeping	1	2	3	4	5	4	80	320	
Staff Meeting Room	1	2	3	4	5	1	200	200	Locate close to, but not within, staff core
Staff Work Room	1	2	3	4	5	1	100	100	Locate close to, but not within, staff core
Staff Restroom	1	2	3	4	5	4	50	200	Provide 2 in work core and 2 in staff respite areas
Staff Locker Rooms	1	2	3	4	5	2	200	400	Shared by outpatient and ED staff, provide shower and locker space

Staff Work Areas (Emergency Department)	Level					QTY	Net Sq Ft	Total	Comments (1540)
Sleep Room	1	2	3	4	5	1	200	200	Provide areas for 4 staff members to sleep (bunks)
Practice Training Room	1	2	3	4	5	1	200	200	Practice room for new equipment and nurse interns
	1	2	3	4	5				Overflow staff sleep room
Remote Monitoring	1	2	3	4	5	1	250	250	Can be located away from core, or at an off-site facility
Staff Respite Area	1	2	3	4	5	1	120	120	Provide access to entertainment and couches
Corridor Equipment Alcoves	1	2	3	4	5	12	10	120	Size to accommodate nesting of mobile equipment
Clean Supply	1	2	3	4	5	1	200	200	Locate close to, but not within, staff core to limit visibility issues
Soiled Utility	1	2	3	4	5	1	100	100	Locate close to, but not within, staff core to limit visibility issues
Equipment Storage	1	2	3	4	5	1	350	350	Locate close to, but not within, staff core to limit visibility issues

Public Areas (Outpatient Services)	Level					QTY	Net Sq Ft	Total	Comments (1480)
Public Toilets	1	2	3	4	5	4	200	800	
Visitor Waiting Areas	1	2	3	4	5	16	30	480	Clustered along the exterior of the building adjacent to patient care areas, arranged into 3 distinct modules
	1	2	3	4	5				Utilize as overflow visitor waiting during mass casualty events
Children Play Areas	1	2	3	4	5	2	100	200	Provide in corners adjacent to visitor waiting areas

Staff Work Areas (Outpatient Services)	Level					QTY	Net Sq Ft	Total	Comments (2070)
MRI	1	2	3	4	5	1	580	580	see manufacturer's specs for further data
MRI Control	1	2	3	4	5	1	100	100	Collocate with CT Scanner control
MRI Patient Preparation	1	2	3	4	5	1	150	150	Large enough to use C-arm if necessary
MRI Dressing/Sub-waiting	1	2	3	4	5	2	80	160	
MRI Patient Toilet	1	2	3	4	5	1	40	40	
Radiology Room	1	2	3	4	5	2	320	640	Locate both rooms together
Radiology Dressing/Sub-waiting	1	2	3	4	5	4	80	320	
Radiology Patient Toilet	1	2	3	4	5	2	40	80	One per radiology room

Staff Work Areas (Outpatient Services)	Level					QTY	Net Sq Ft	Total	Comments [2320]
CT Scanner	1	2	3	4	5	1	400	400	See manufacturer's specs for further data
CT Control	1	2	3	4	5	1	100	100	Collocate with MRI control
CT Patient Preparation	1	2	3	4	5	1	150	150	One area for stretcher, recliner
CT Dressing/Sub-waiting	1	2	3	4	5	2	80	160	
CT Patient Toilet	1	2	3	4	5	1	40	40	
Ultrasound Room	1	2	3	4	5	2	140	280	Size to include use of mobile US equipment
Ultrasound Dressing/Sub-waiting	1	2	3	4	5	4	60	240	
Ultrasound Patient Toilet	1	2	3	4	5	2	40	80	
Digital Systems Room	1	2	3	4	5	1	250	250	Contains large CPU units required to operate imaging equipment
Reception/Scheduling	1	2	3	4	5	1	80	80	
Registration	1	2	3	4	5	2	80	160	Combine into one large space adjacent to vertical circulation
Staff Work Area	1	2	3	4	5	1	100	100	Provide digitally integrated counter work surface
Tech Work Area	1	2	3	4	5	1	180	180	Workspace, digitizer equipment
Radiologist Interpolation	1	2	3	4	5	1	100	100	

Staff Work Areas (Outpatient Services)	Level					QTY	Net Sq Ft	Total	Comments (1010)
Corridor Equipment Alcoves	1	2	3	4	5	4	10	40	Size per mobile imaging equipment
Staff Offices	1	2	3	4	5	2	100	200	Collocate with emergency service offices
Staff Restrooms	1	2	3	4	5	2	50	100	Within department
Clean Supply	1	2	3	4	5	1	100	100	Smaller size than ED will work
Soiled Utility	1	2	3	4	5	1	100	100	Smaller size than ED will work
Equipment Storage	1	2	3	4	5	1	150	150	
Housekeeping	1	2	3	4	5	4	80	320	Disperse throughout department

Staff Work Areas (Life Support Structure)	Level					QTY	Net Sq Ft	Total	Comments (3600)
Solar Screen	1	2	3	4	5	1	TBD	TBD	PV integration into any available space in correct solar orientation
Communications Center	1	2	3	4	5	1	500	500	Oversize for appropriation
Staff Parking	1	2	3	4	5	1	1500	1500	Oversize for appropriation, include connections to med gas, power, water
Storage	1	2	3	4	5	2	200	400	Cooled for ice storage
Digital Water Tower	1	2	3	4	5	1	1200	1200	Storage for 50000 gal of water w integrated digital interface

Programmatic Focus Areas

A thorough analysis of the basic throughput process reveals critical focus areas within the emergency care environment that are indicative to its effectiveness, including the entry triage area, patient exam room, and staff work core. Further analysis of the focus areas yield important information about the location, orientation, and type of information technology utilized during the care process.

Entry Triage // The layout and design of the entry triage area is critical to the success of the emergency department as it is the space in which the entire throughput process is initiated. The design of this space extends to the exterior of the building, with front entry points needing to be clearly demarked for ease of wayfinding. Once inside, the triage staff utilizes rapid eye assessment and verbal communication to initially gauge potential patients. After the initial greeting and assessment are complete, the staff members input information (name and birth date) into a computer terminal, effectively initiating each patient's digital existence within the constructs of the healthcare system. Typically, patients are then moved to a waiting area (separate or isolated) adjacent to a series of triage rooms. Patients are then pre-screened by a triage nurse,



134. Typical Layout of Entry Triage
2002 // Huddy

who conducts registration and then determines their placement within the overall unit. While this model may be the best way to handle the large crowds experienced at an urban trauma center ED, for smaller facilities it can add unnecessary steps into the process. Typically in smaller facilities these areas would still be present, but lie mostly dormant and are only be utilized during peak periods of utilization. In order to expedite throughput, the recommended operational triaging process is to move patients directly to treatment areas and perform registration at the bedside. In room registration effectively removes unnecessary steps from the overall process, minimizing patient wait times and mixing with other people (Huddy, 156).

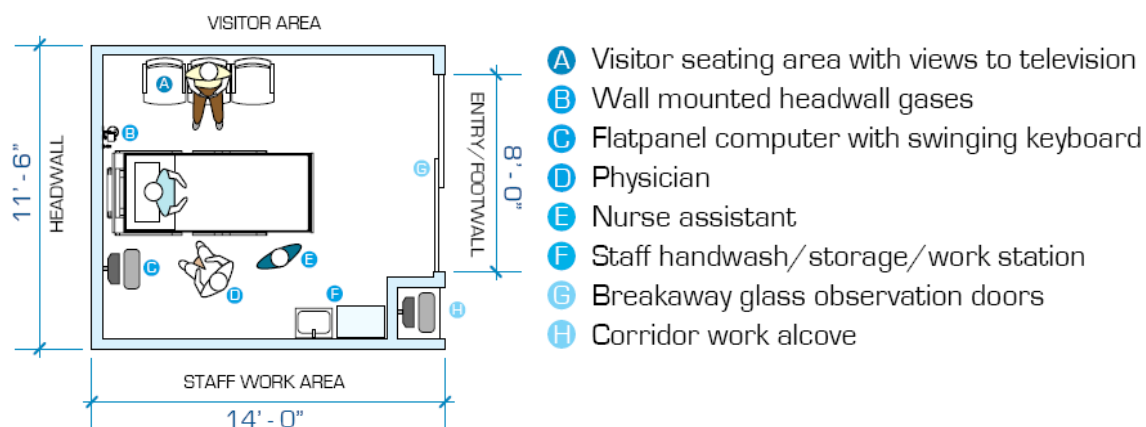
The waiting area is a critical consideration in the design of entry triage. The most typical type of waiting area is the large, centralized space which combines patient and visitor populations into one. This model is an ineffective approach because it forces conflicting populations (healthy vs. sick, victim vs. perpetrator, gang vs. gang, etc) to coexist within one single space. The first degree of deconstruction in this space can begin with the inclusion of separate private patient waiting areas. This enables staff to filter the population in the primary public waiting area down to only visitors. As illustrated by the Swedish Medical precedent study, clustered waiting areas are a way

to further filter large crowds into smaller, intimate groupings. Connections to digital resources in the clusters further strengthen the facility's ability to provide visitors with a sense of comfort and control, as well as positive distractions. These platforms could also be utilized to provide information to visitors such as projected wait times, educational resources, and wayfinding.



135. Callison Freestanding ED Triage and Decentralized Waiting Areas (Beige) along Exterior
2006 // Callison Architects

Patient Examination Space // The design of the patient examination space is directly related to the overall layout of the entire unit. The base model for the patient examination space was based on the recommendations of Jon Huddy in “Emergency Department Design: A Practical Guide to Planning for the Future”. In an ideal condition, patient registration, examination, and treatment would occur in a single, universal care space (termed a patient examination space in this case), ranging from 150-160 sq ft in total size (Huddy 127). Each patient examination room has access from one side, with the bed positioned on the opposite wall. Ideally, this enables staff members in the work core to have visibility to all of their patients and easy access to both sides of the patient.



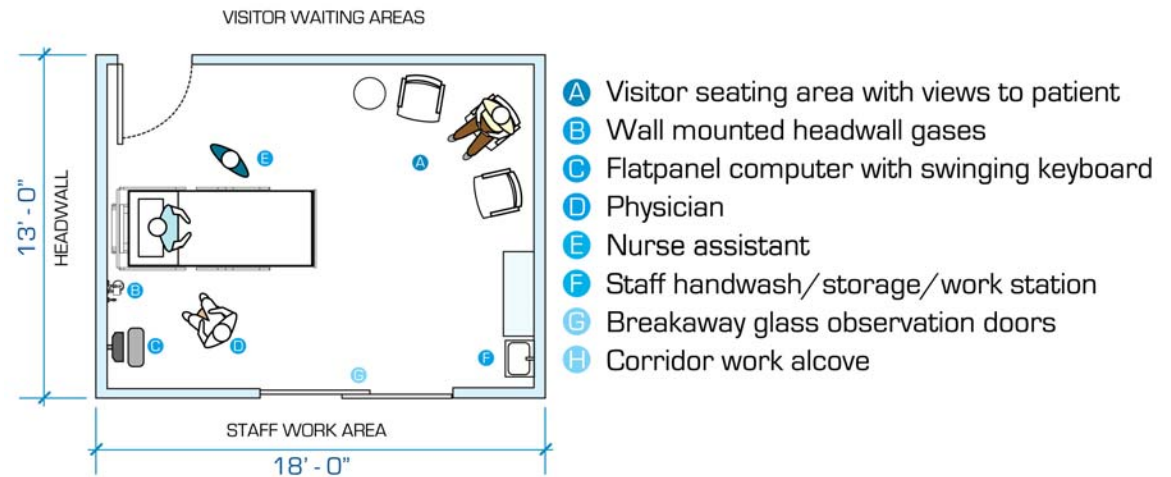
136. Typical Patient Room Configuration

2006 // Ruthven

The room is then split between family and staff work areas on each side. The family area typically includes chairs and visibility to entertainment platforms (television). The staff area includes a sink, work surface, and computer station. In some cases, exam rooms will have an additional computer console in a decentralized corridor alcove adjacent to the room. The layout of examination rooms in this manner forces different types of circulation to mix together, with staff, patients, and visitors all accessing the space from a single entry point.

If the unit is to be organized into the layers of penetration that divide public and service circulation into two distinct zones, the configuration of the patient exam space must be altered accordingly. Furthermore, in order to accommodate an increase in capacity each room must be at least 225 sq ft. Otherwise, the staging of an additional gurney in that space during mass casualty events would be compromised. While not planned for surge capacity, the Swedish Medical Freestanding Emergency Department features a similar universal room concept for patient care spaces (234 sq ft). Each room is accessible from both sides, enabling separation of public and service circulation paths. The bed is positioned parallel to the staff core, with visibility being

retained through the usage of glass breakaway doors. Staff and family zones are clustered along the footwall.



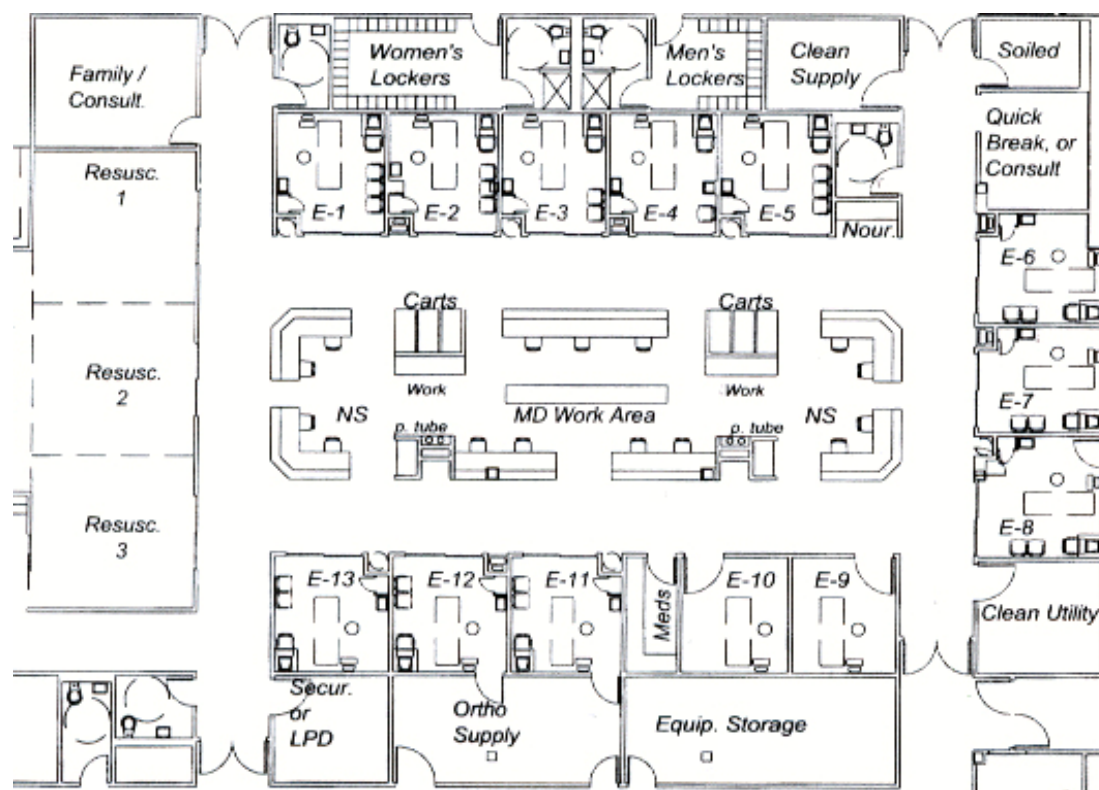
137. Swedish Medical Freestanding Emergency Department Patient Room Configuration
2007 // Ruthven

Staff Work Core // Major considerations when designing a staff work core are to minimize the overall footprint and maintain close connections with support spaces (clean supply, soil utility, etc) for efficiency, as well as maximize visibility to all patient care areas for safety and control. In order to minimize the overall footprint, it is important to organize patient rooms into contiguous, tightly grouped modules around a



138. 'Fishbowl' Concept - Spartanburg Regional Healthcare System ED
2006 // Ruthven

centralized work core. Visibility across the unit can be achieved through the 'fishbowl' concept, or eliminating any full height interior partitions and enclosed support spaces for the central work core area. The support spaces are pushed to the periphery of the unit, forming its outmost ring of spaces. Computer consoles at the central nurse station are oriented to face the patient care spaces, enabling staff to retain visibility while charting information.



139. Emergency Department Unit Design - Contiguous Modules and the 'Fishbowl' Concept
2002 // Huddy



140. Swedish Medical FED: Central Nurse Station with Limited Visibility to Patient Care Areas

2006 // Callison Architects

The organization of the Swedish Medical illustrates a conflict between the idea of ‘double accessible’ patient exam rooms and the ‘fishbowl’ concept for maximum visibility. Since the patient rooms are accessible from both sides, the support spaces can no longer be placed around the unit periphery because they would block visitor access. The only solution is to locate the support space within the staff core, which minimizes visibility to the patient spaces. The resolution of this issue was a critical design consideration in the final design of the thesis proposal.



141. Swedish Medical Freestanding Emergency Department Staff Core Configuration

2005 // Callison

GROUNDING CONCEPTS: SITE VIABILITY AND CONSIDERATIONS

With the right combination of orientation and materials, an architect can transform an awkward property near a freeway into a house with a million - dollar view.

Andrew Blum

Writer for "Metropolis" Magazine (1968 -)



142. Focus on Site + Location
2007 // Ruthven

In order for the project to explore an improved response to disaster situations, it was located in a densely populated area within a region which is susceptible to a wide range of possible mass casualty events, such as hurricanes and terrorist attacks. 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.

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, 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.

The selected land within the urban environment adheres to an established set of site criteria. It is a stable, elevated site which is available, properly zoned, adjacent to major arterials/infrastructure, and within a rapidly expanding, non-historical sector of the city. By meeting regional and urban conditions defined in the criteria, the site strengthens the building's overall ability to deliver care during both daily and surge conditions, as well as make a case for its practicality within the existing healthcare infrastructure of Charleston County.

Regional Selection Criteria



143. City of Charleston, SC
2007 // Getty Images

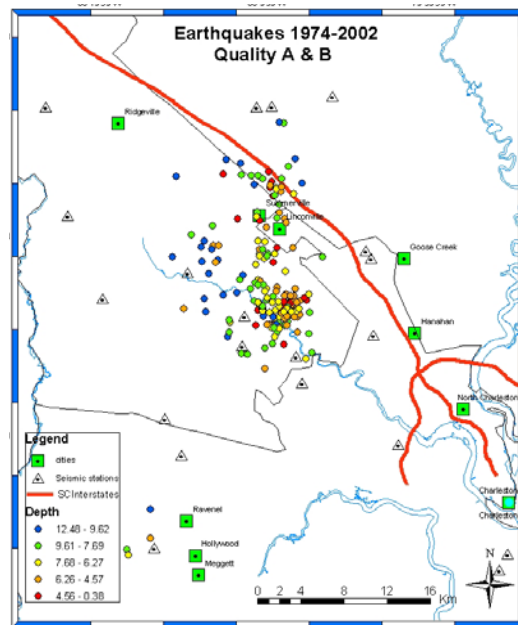
The following criteria were established to ensure that regional demand and proper transportation infrastructure for emergency care services were present in the Charleston, SC region. A historical analysis was conducted to determine if the area was vulnerable to large scale natural disasters such as hurricanes, floods, and earthquakes, ensuring that the potential to generate volumetric patient surges existed. Additionally, a population and disaster preparedness analysis was conducted to ascertain if regional demand merited the implementation of additional emergency care services.

A Historical Overview // The Charleston region of South Carolina has a rich history that dates back to pre-Revolutionary times. However, the area has been prone to natural disasters due to its position in an active seismic zone and along the coast of the hurricane producing Atlantic Ocean. In a little over the past 100 years, two major



144. Destruction to MUSC after the Earthquake of 1886

1886 // scsn.seis.sc.edu



145. Current Increase in Seismic Activity

1886 // scsn.seis.sc.edu

natural disasters (the Earthquake of 1886 and Hurricane Hugo) have come to define the need for a strong emergency response infrastructure and level of preparedness.

The Earthquake of 1886 in the Coastal Plain near Charleston came to define the seismic history of the southeastern United States. It also represents one of the largest earthquakes to hit the eastern seaboard of North America. The major shock, which lasted less than one minute, occurred on August 31, 1886 at approximately 9:50 PM, resulting in roughly 60 deaths and extensive destruction to the city of Charleston. The meizoseismal area, or area of maximum damage, of the quake is an elliptical roughly 20 by 30 miles, centered at Middleton Place. Geologists suggest that this quake was just the beginning of more to come, as 300 of the 475 significant earthquakes reported from 1754 to 1975 were aftershocks of this earthquake. They warn that increased activity in the past 25 years may be an omen that another large quake is just around the corner (Talawani, 01).

The other major natural disaster to strike the Charleston region in the last century was Hurricane Hugo on September 21, 1989. Upon landfall, the category 4 storm



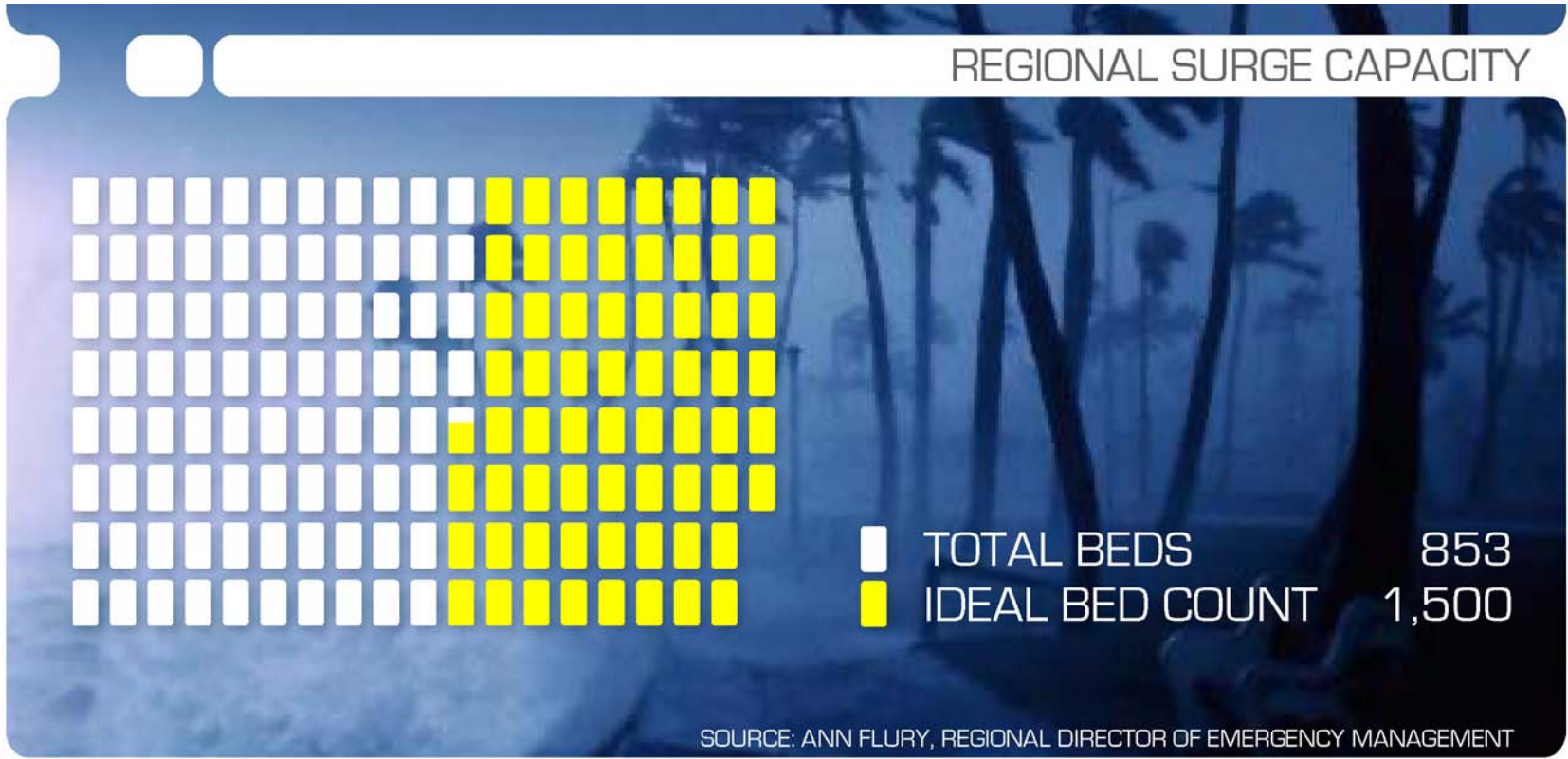
146. Satellite Image of Hurricane Hugo
1989 // Getty Images

caused significant destruction to the urban center of Charleston, with its worst devastation being experienced in the surrounding areas of Mount Pleasant, Sullivan’s Island, and Isle of Palms due to their position north of the eye wall landfall directly over the City. A 20 foot storm surge and high winds reaching in excess of 120 mph were blamed for the majority of the damage. The storm caused a humanitarian crisis, killing 86 people and leaving 56,000 homeless and \$13.6 billion dollars worth of damage behind. Had the eye passed just south of the city, the destruction on peninsular Charleston would have been even more severe. Extensive relief was provided by the Red Cross, the Salvation Army, local churches, and eventually FEMA (which received criticism for its ‘surprisingly’ slow deployment).



147. Destruction on Sullivan’s Island from
Hurricane Hugo
1989 // Getty Images

Significant improvements to regional healthcare and preparedness infrastructure came in response to the destruction and chaos caused by Hurricane Hugo. An extensive network of shelters was set up in anticipation of the widespread homelessness caused by such storms. Healthcare infrastructure was also upgraded during this time, but as of 2007 still falls short of the desired amount of available beds to be utilized during a disaster event (with 853 available and 1,500 desired) (Flury, 01).



- 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/port connections

148. Regional Surge Capacity
2007 // Ruthven



149. MUSC Expansion Project
2006 // HOK Architects

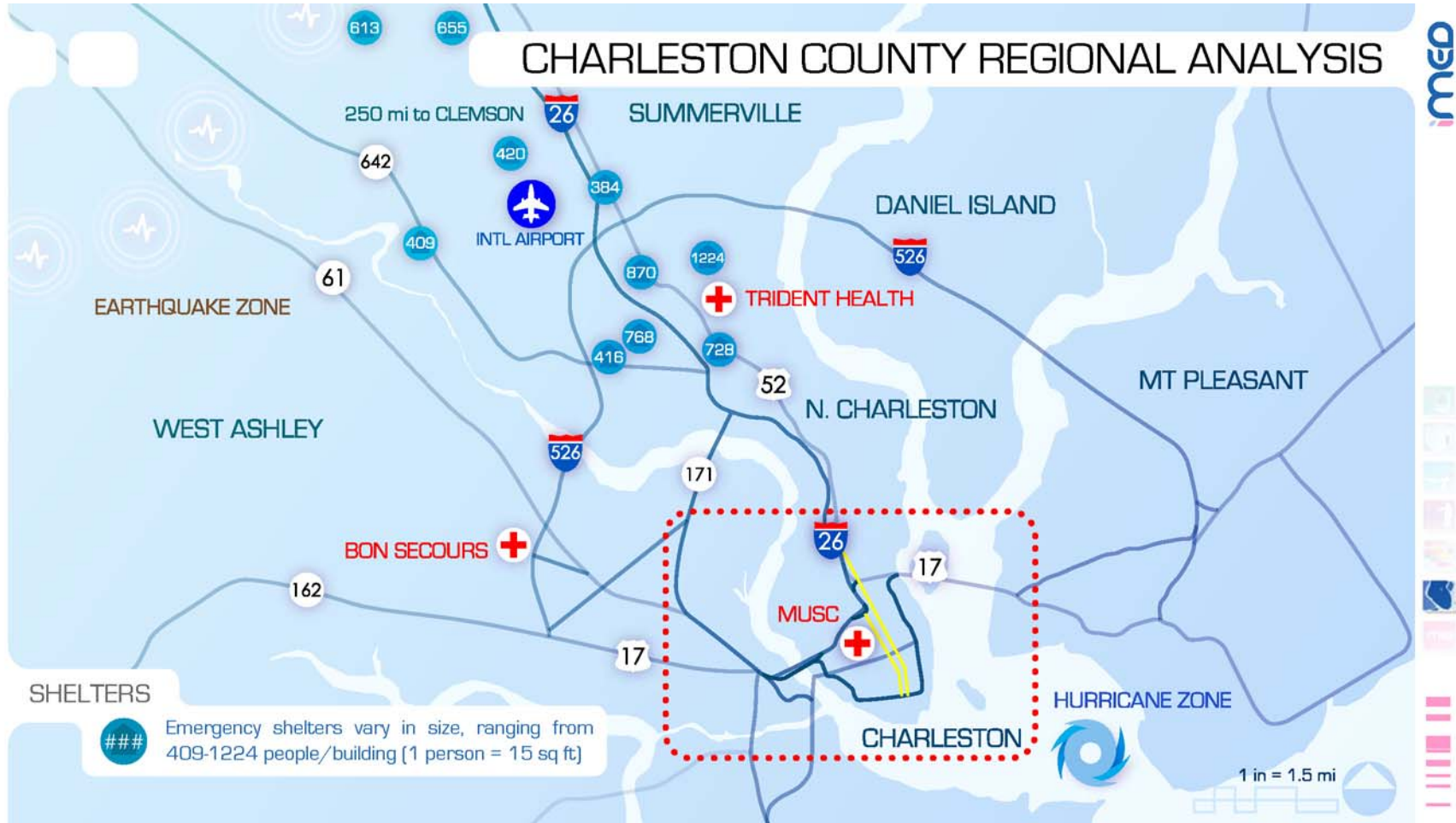
Population Considerations // Despite its location in a disaster prone region, the Charleston metropolitan area of South Carolina has been experiencing a period of tremendous population growth during the past decade. In the city of Charleston alone, the population has increased nearly 23% from 1990 - 2002 (from 80,414 to 104,000), or nearly 2% per year (City of Charleston, 03). This rapid increase in population has contributed to a massive overhaul of the regional healthcare infrastructure, most notable being the Medical University of South Carolina (MUSC) replacement hospital project.



150. MUSC Expansion Project
2006 // HOK Architects

In an age when terrorism has unfortunately become a reality, the increase in population density within the urban center has also heightened the possibility of it being targeted for a terrorist attack. International seaport and air connections further increase this potential, as they experience travelers, goods and material from all points of the globe. While preparedness in the region has primarily been focused on natural disaster recovery, its planning measures have come to include preparations for man-made as well as natural disaster events. However, in a recent report in which Department of Homeland security ranked preparedness of 75 regions in US,

Charleston County did not receive high marks [Thomas, 01]. Additional healthcare and emergency response infrastructure in the region is needed.



151. Charleston County Regional Analysis
2007 // Ruthven

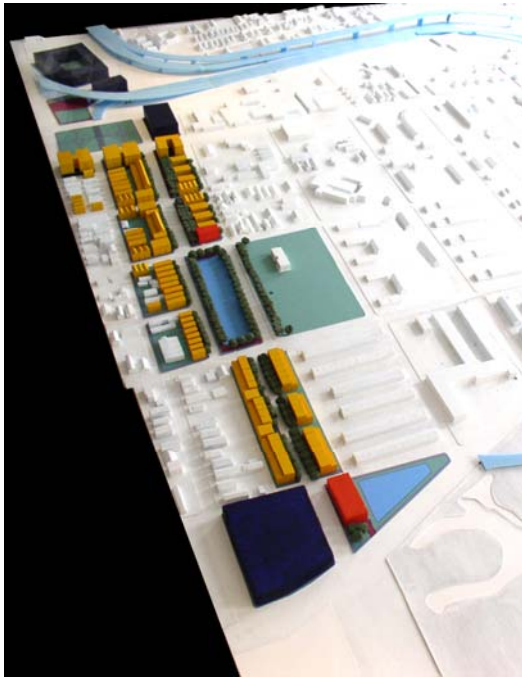
Site Selection Criteria



152. City of Charleston, SC
2007 // Getty Images

The selection of the city of Charleston as the urban context in which to locate the site was based on conditions which make it a suitable environment for the implementation of a freestanding emergency care facility. These conditions include significant developments along the periphery of the city in response to rapid population growth, recent improvements to regional infrastructure in those areas, and an inability for existing healthcare facilities to deliver care during mass casualty events.

Developing Areas // 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. Three significant developments are in the various stages of planning and implementation for that northern area, including the Cooper River Bridge Redevelopment Project, Magnolia Plan, and Golf Course Plan. The development which remains closest to the existing dense urban fabric of Charleston is the Cooper River



153. Model of the Cooper River Redevelopment Project
2006 // Charleston Center for Civic Design

Bridge Redevelopment Project. 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 repair 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 (light industrial, mixed use, and abandoned buildings).



154. Re-knitting the Neighborhood Fabric
2006 // Charleston Center for Civic Design

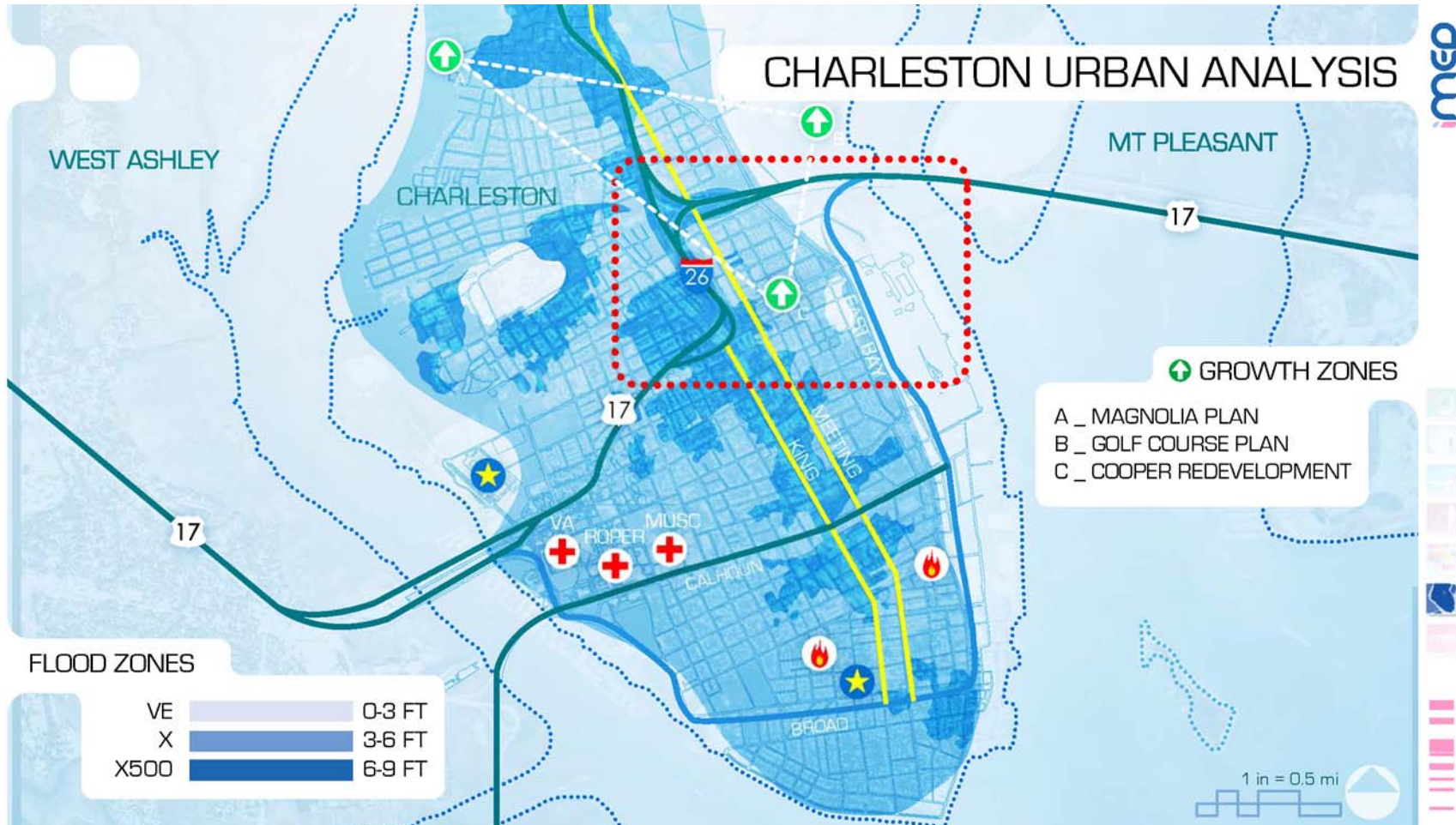


155. Critical Healthcare Infrastructure Low in the Floodplain of Charleston, SC
2007 // Ruthven

Inadequate Existing Healthcare Infrastructure // 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 above sea level.

The detrimental impacts of locating these vital regional healthcare elements low in the flood plain were illustrated during Hurricane Hugo, when the storm surge effectively disabled the 1st and 2nd floor of all the facilities. Not only was equipment, paper records, and furnishings lost, the healthcare infrastructure was collectively unable to admit any new patients for a consideration portion of time after the storm. Patients were forced to be transported to surrounding regional facilities for care at the detriment of their heal status (Flury, 01). Other critical regional preparedness infrastructure elements

including police and fire stations were also hindered as a result of poor location during the storm.

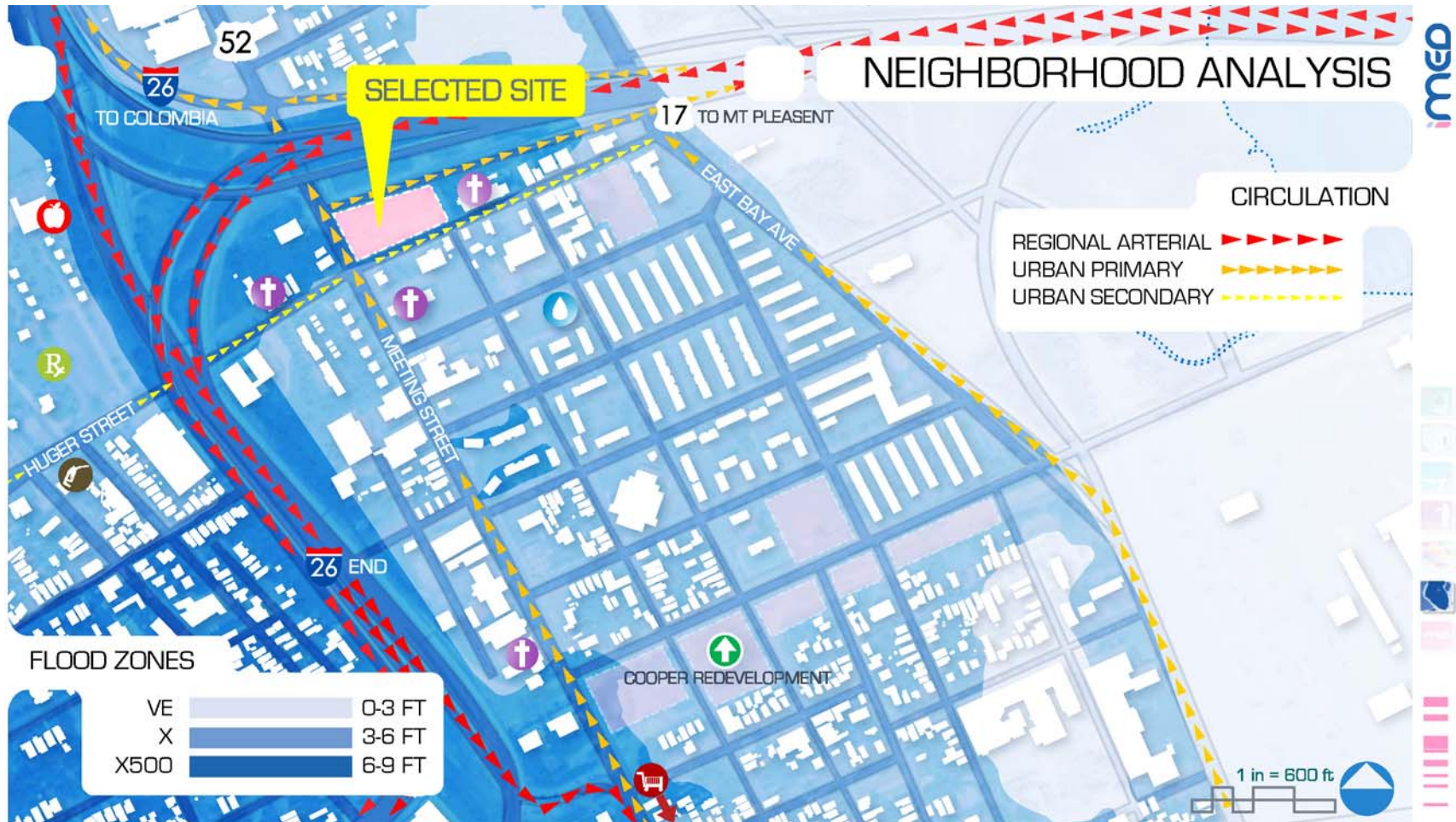


156. Charleston Urban Analysis
2007 // Ruthven

The Cooper River Bridge Redevelopment neighborhood was ultimately selected for the location of the proposed freestanding emergency department proposal because of its availability of portions of the peninsula which are of the highest elevation (6 – 9 ft), its proximity and access to developmental growth areas associated with the population boom, and lack of sensitive historical context.

Site Selection Criteria // A series of criteria were established to select the specific site for the implementation of the freestanding emergency care facility. These criteria include proper zoning (non-residential), availability of land, location near developing growth areas (for capture of expanding patient population), and adjacent to major vehicular arterials serving both the city and region for maximum accessibility. The site for such a facility should also accommodate the multiple potential scenarios associated with the identified range of mass casualty events. The site should allow the, shielding and enabling of the facility to operate effectively by being on high, stable land to limit damage from flooding and earthquakes, and adjacent to infrastructure elements for appropriation as needed during and after these events(bridge overpasses, churches, schools, green spaces, fresh water supply, etc.).The selected

site is appropriate for the implementation of an emergency care facility because it is a stable, elevated (for Charleston) site which is available, properly zoned in a non-historical area, adjacent to major arterials and infrastructure, and within a rapidly expanding population sector of the city.



157. Final Site Selection within the Cooper River Bridge Redevelopment Neighborhood
2007 // Ruthven



158. Triangle of Development in Northern Charleston, SC
2007 // Ruthven

While currently zoned as light industrial, the zoning for the site can accommodate general business uses, which also enables development of outpatient healthcare buildings. Additionally, the surrounding areas are all zoned light industrial, containing buildings of little historical significance to the city. The site is situated at the center of a triangle of projected development, including the Cooper River Redevelopment Plan to the south, the Magnolia plan to the northwest, and the Golf Course Development to the northeast. 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).

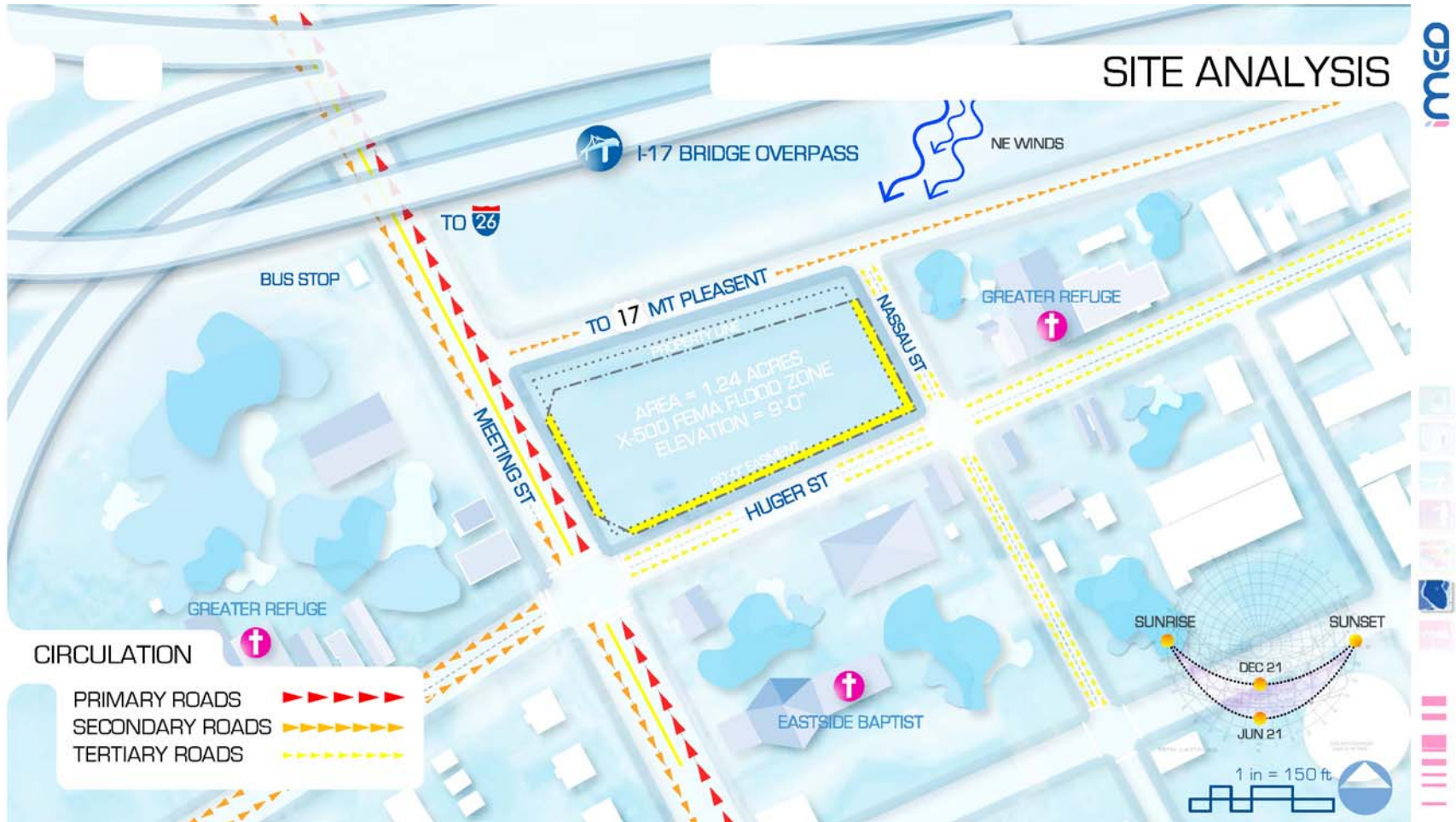


159. Non-historical Site Context
2007 // Ruthven



160. I-17 Bridge Overpass Adjacent to Site
2007 // Ruthven

Additionally, the site 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. The land is in the X500 FEMA flood zone, the highest in the city, at an elevation of 9'-0" above flood plain. 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 expansive, open area beneath the I-26 and I-17 highway overpasses could be utilized as a staging area for relief agencies, although it would require infill in areas to raise it above the floodplain further. Additionally, three churches in the immediate vicinity of the site could be appropriated for use as shelters and points of distribution areas for relief supplies. Other key infrastructure includes a major food distribution center (Piggly Wiggly) to the south of the site (0.7 miles) and a clean water storage tank to the south east (0.2 miles).



161. Site Analysis
2007 // Ruthven

An Area of Need // In order for the facility to demonstrate an improved response to disaster situations, it was located in a densely populated area within a region which is susceptible to a wide range of possible mass casualty events, such as hurricanes and terrorist attacks. Determination of the site criteria were driven by the building's ability to effectively accommodate the proposed programmatic needs during daily operations, as well as prepare it for mass casualty events. The selected land adheres to the established site criteria because it is a stable, elevated site which is properly zoned, adjacent to major arterials/infrastructure, and within a rapidly expanding, non-historical sector of the city. By meeting regional/urban conditions defined in the criteria, the site strengthens the facility's overall ability to deliver care during both daily and surge conditions, as well as make a case for its feasibility within the existing healthcare infrastructure of Charleston County.

THE INTERACTIVE MEDICAL EMERGENCY DEPARTMENT [iMED]

Design is not just what it looks like and feels like. Design is how it works.

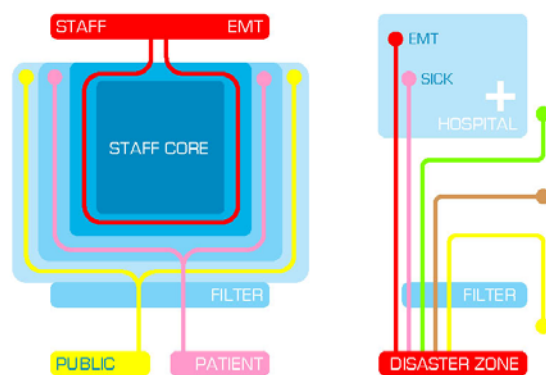
Steve Jobs

CEO of Apple (1955 -)



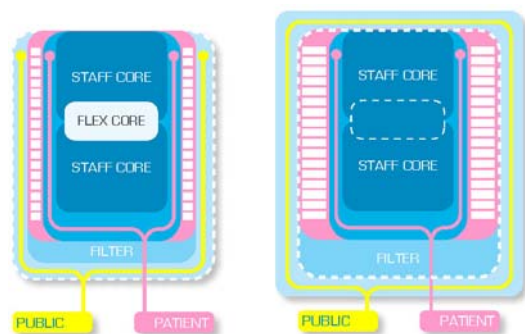
162. Focus on Proposal
2007 // Ruthven

The architectural proposal is intended to serve as a catalyst for the integration of information technology into the framework of the healthcare environment. The quality and effectiveness of care delivery within this technologically integrated environment is improved by increasing access to information sources, improving flexibility which enables the facility to adapt to changing conditions, and streamlining spatial clutter in order to remedy the healing environment. The building becomes a digital interface to the community through its exterior as well as on its interior, increasing its ability to input, access, and transmit data to the surrounding population and its occupants. As digital interface elements become more ubiquitous within the environment, accessibility and privacy concerns were addressed by conceptualizing all physical thresholds as digital scanners, enabling the building systems to recognize and adapt in order to appropriately accommodate individual needs and rights to access information. Additional security and control are enabled by organizing the facility into layers of penetration, with public circulation located along the exterior of the building,



163. The Layers of Penetration - Daily vs. Surge Operations
2007 // Ruthven

internalizing staff work areas, and placing patient care spaces at the intersection. These layers of penetration were designed to be able to expand like a sponge in order to accommodate the increased levels of patients experienced during mass casualty events by reusing non-critical spaces [such as visitor waiting areas] for surge bed placement, as well as adapting existing areas such as the patient exam room to increase occupancy loads. Recognizing that the healthcare facility cannot do everything on its own during mass casualty events, appropriation of existing infrastructure elements (including a highway overpass, churches, and parking surfaces) spread out the capabilities of the building, allowing it to become a Point of Distribution (POD) staging site for disaster relief agencies. The underlying assumption of the project was that the effectiveness and efficiency of care delivery could be improved during both normative and surge conditions by using the outlined framework as the conceptual drivers for the design of the freestanding medical emergency care facility. This proposal chapter is organized to transition in scale from the urban context, to the overall building, and finally to the interior resolution of the three focus areas (entry triage, patient examination area, and staff work core), illustrating the role and purpose of the environmentally integrated digital systems at each specific level.



164. Building as Sponge
2007 // Ruthven

Urban Design Elements

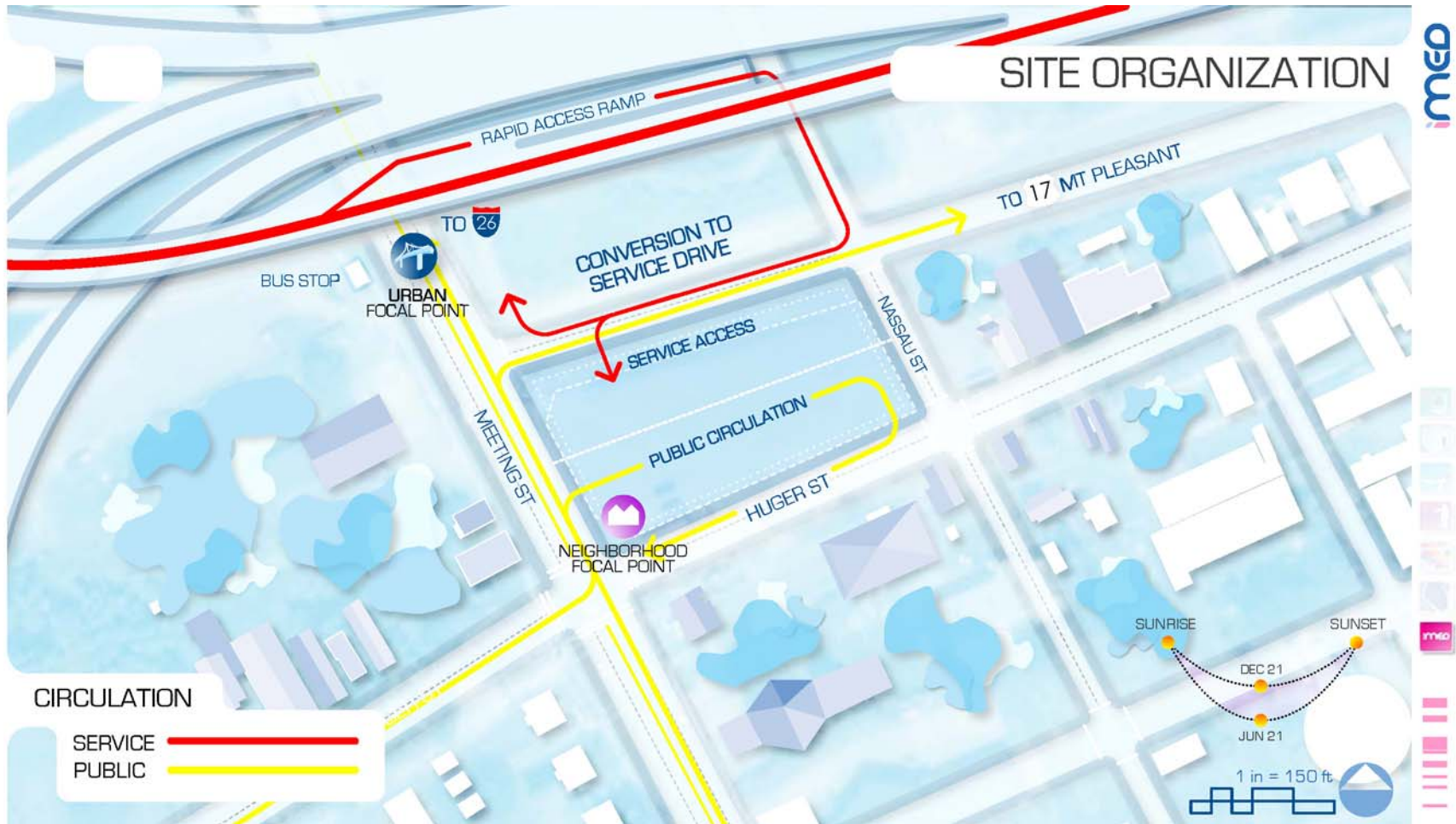


165. Urban Scale
2007 // Ruthven

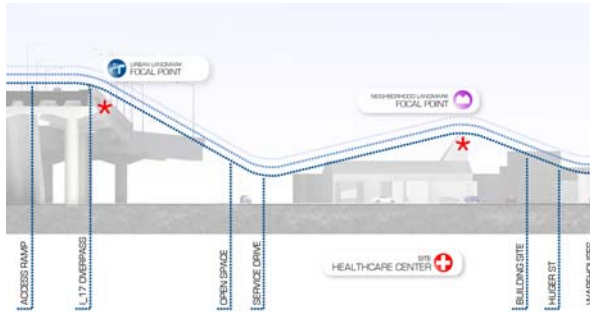
At the urban scale, the site organization, appropriation of surrounding infrastructure, and orientation/scale of digital interface elements were guided by accessibility, location of existing elements, and visibility concerns respectively.

Site Organization // 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. Public and service circulation areas were divided between the northern and southern portions of the site, collocating service functions with the highway overpass and positioning public areas to open out towards the greater city of Charleston to the south. 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. Additionally, the portion of the street adjacent to the site which leads to the I-17

onramp was converted to a two-way street (Service Drive), increasing the flexibility of the facility by enabling unrestricted movement to and from the service area of the facility.



166. Site Organization
2007 // Ruthven



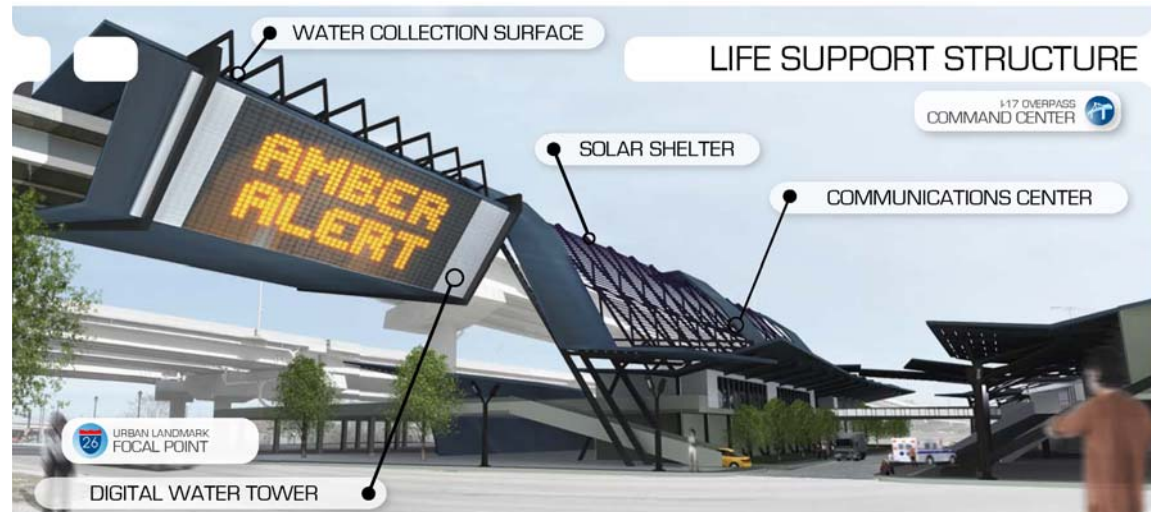
167. Transitional Site Condition
2007 // Ruthven

Life Support Structure // 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.



168. Utilization of Transitional Condition for Design Interventions of Digital Elements
2007 // Ruthven

Recognizing that both a clean water source and digital urban interface required the elevation provided by the overpass, a digital water tower was conceived in which both functions were layered together into one seamless element. The refuge areas under the overpass were strengthened and expanded by incorporating a solar shelter into the southern exposure, enabling a self-sustaining source of power generation for the facility and screening element for potential staging operations under the bridge. A digital command center, including a communications room, storage areas, and expanded parking area, round out the base of the life support structure. Each element was oversized in order to accommodate staging efforts by disaster relief agencies.

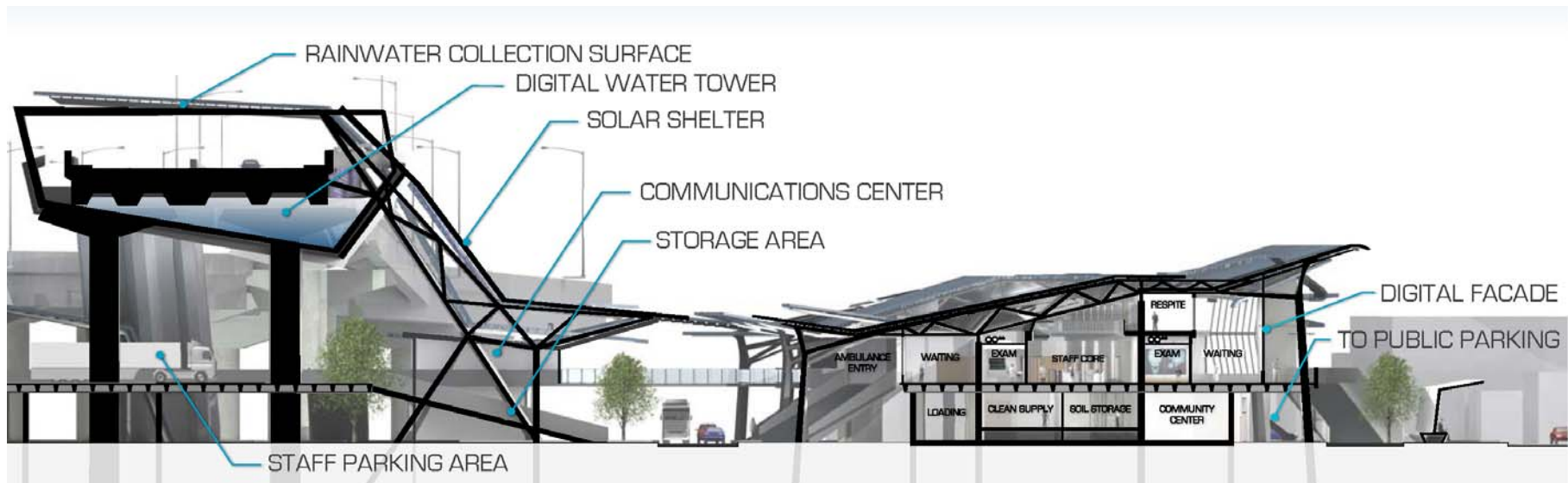


169. Life Support Structure
2007 // Ruthven



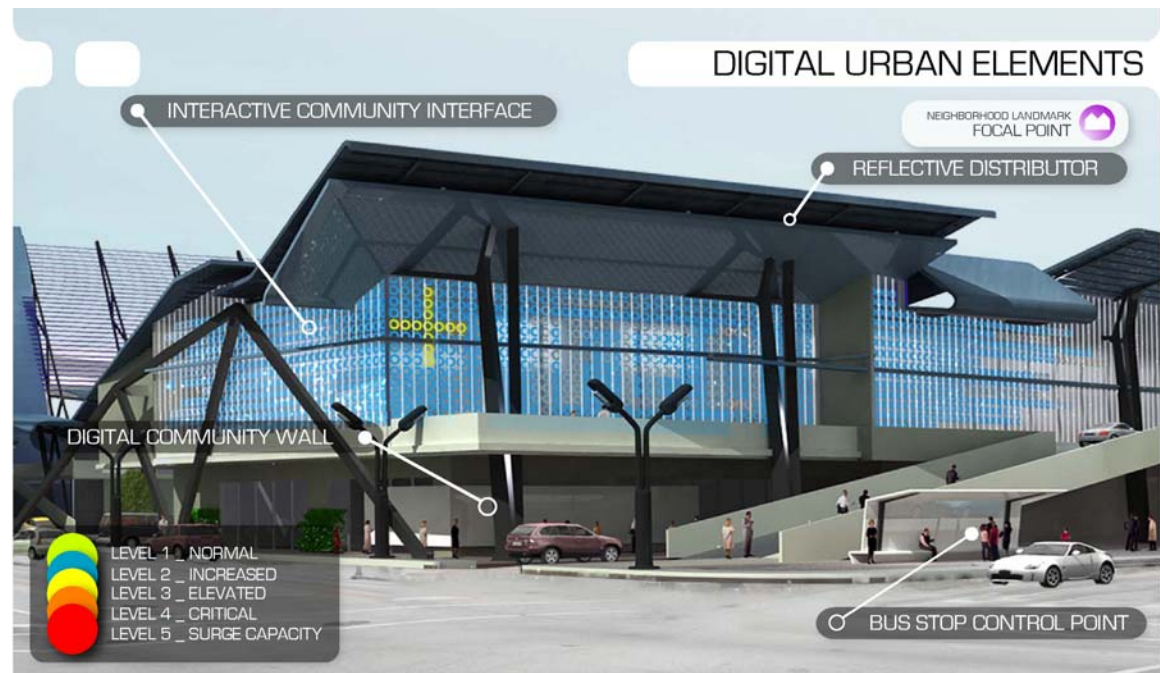
170. Critical Juncture: Meeting and Huger St
2007 // Ruthven

Critical Urban Juncture // The location and scale of the integrated façade display 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. Placement on this corner enables the facility to be visible down both vehicular corridors, most notably Meeting Street which extends into the heart of the city. Visibility was the major driver for the design of the digital elements, as the primary role of the integrated facade interface was to discern the level of activity within the building. The color of the display (controlled internally by staff) represents an indicator of internal conditions within the emergency care environment, shifting from green during normative operations down to red for surge capacity.



171. Site Section through Meeting Street
2007 // Ruthven

Additionally, the capabilities of the integrated façade were extended by instituting a digital bus stop control point at the critical vehicular juncture in order to extend the accessibility of services to urbanites who utilize the mass transit network. The bus stop serves as a control point for the large format integrated digital façade display, with users being able to customize lighting patterns on the exterior of the building to create messages, pictures, or mixture of both. This enables the façade to remain informative while being interactive, further increasing its ability to have civic value to the community.



172. Digital Community Interface at the Corner of Meeting and Huger Streets
2007 // Ruthven

Building Design Elements

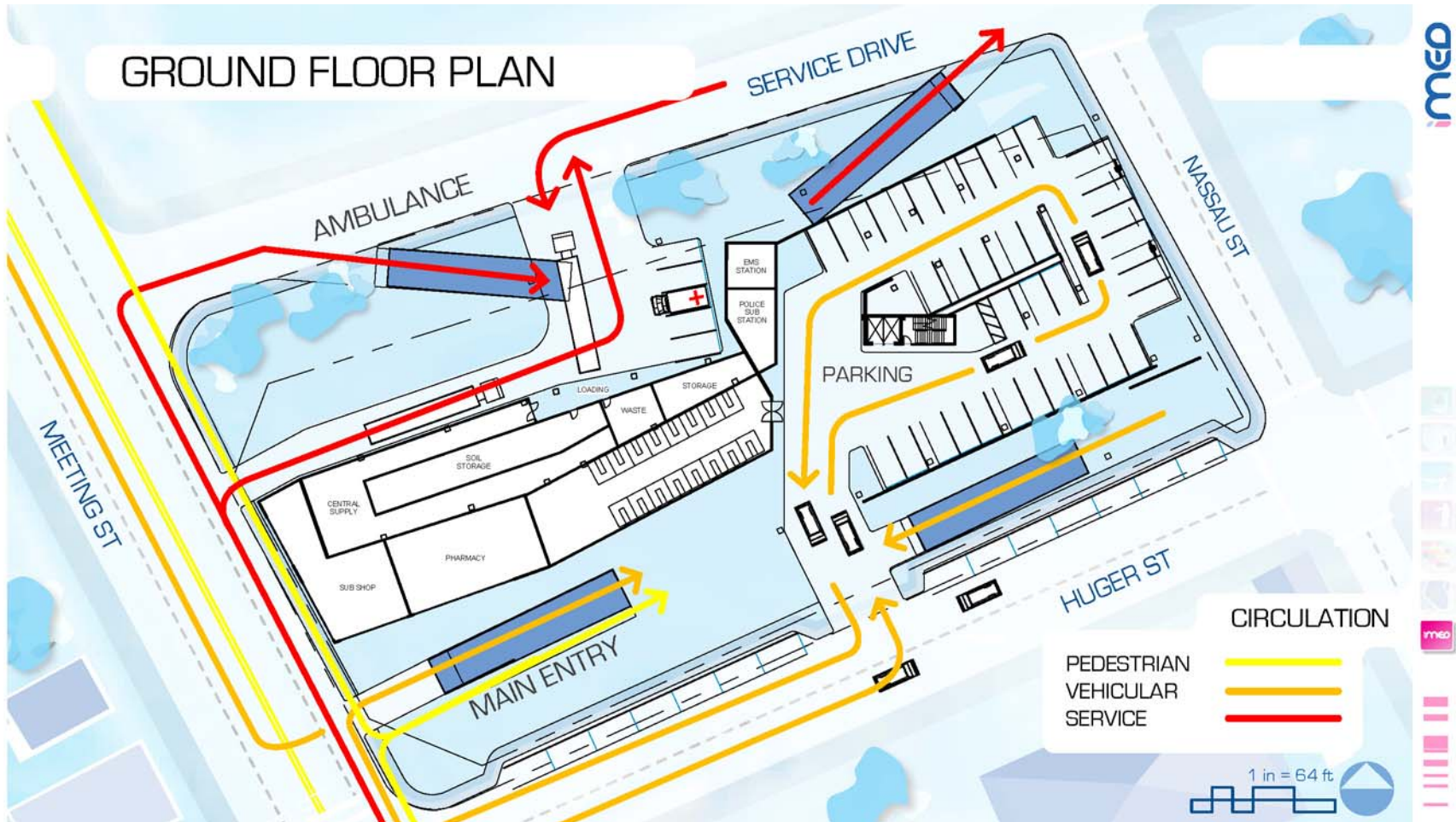


173. Building Scale
2007 // Ruthven

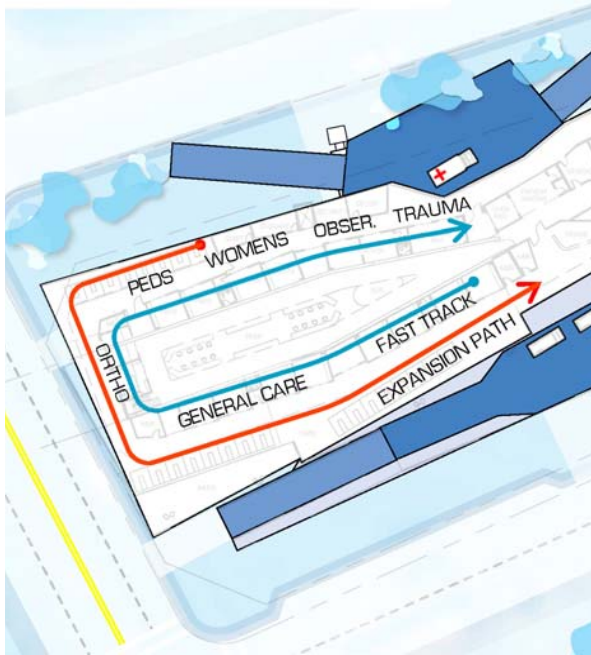
While the site was selected along the highest ground on the Charleston peninsula, a major consideration for the layout of the facility was its elevation above the floodplain in order to withstand a potential 20' storm surge. This divided the building into two distinct zones, with functions that were not critical to the continuing operation of the facility (community services, parking, etc) being located on the ground level, and the vital healthcare infrastructure (emergency and imaging departments) elevated on the first level.

Ground 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 (in the form of a soup kitchen, homeless

shelter, clinic, education center, etc). A digital community wall element was integrated into the exterior façade of the community center to enable public accessibility to medical and educational information.

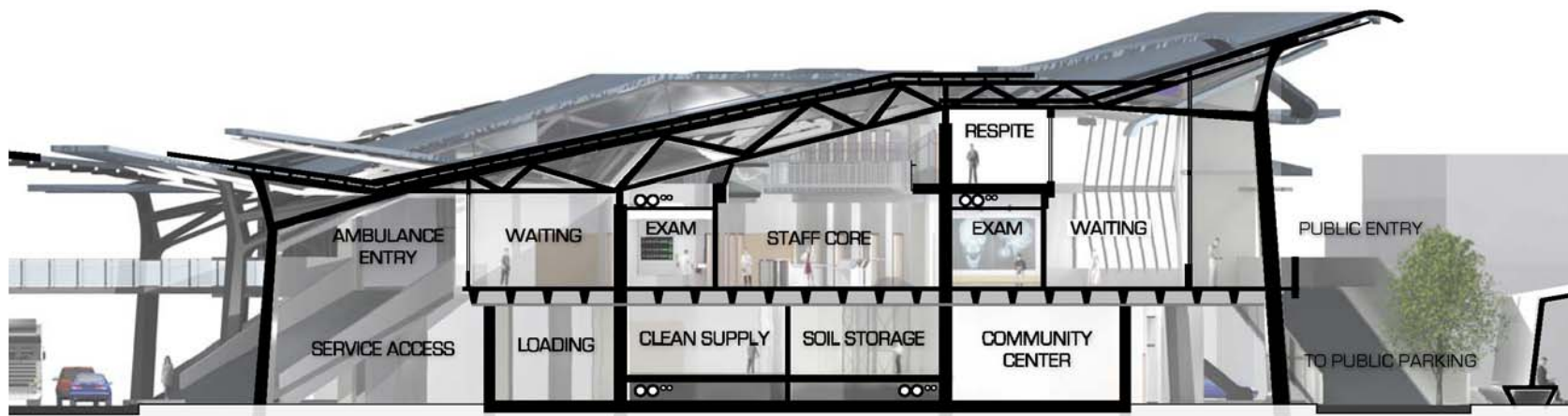


174. Ground Level Floor Plan
2007 // Ruthven

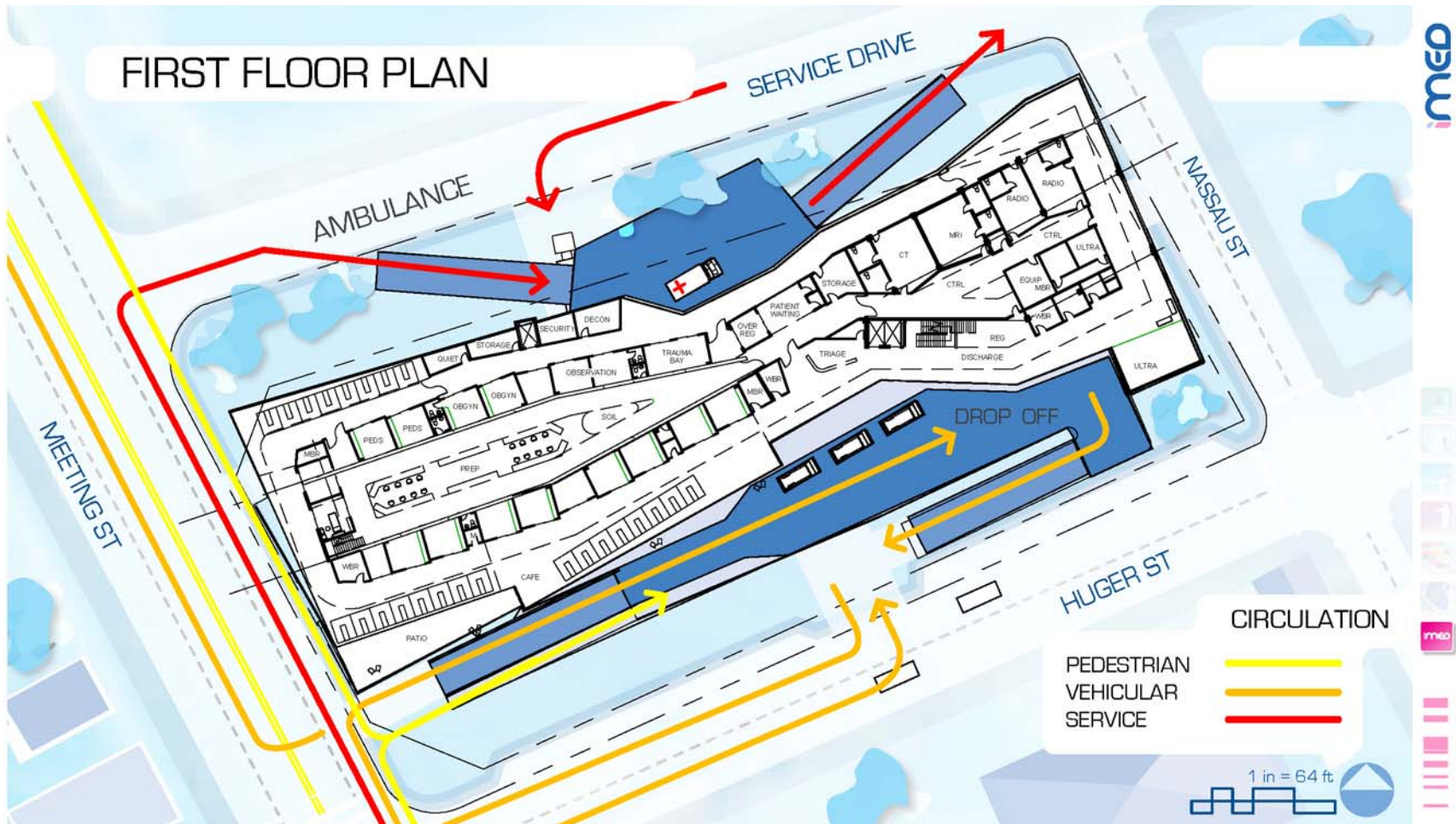


175. Unit Design: Acuity Loops
2007 // Ruthven

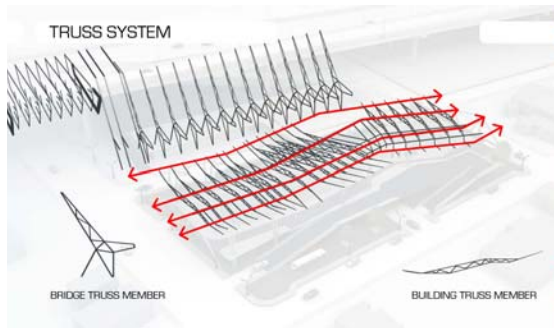
First Level // Critical medical care areas were elevated in order to control access to the facility as well as protect it from a potential 20 foot flood surge. The floor was split between imaging services (east) and emergency care area (west), both of which are accessed through a central entry point 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 step down in form of the facility further strengthens this organizational acuity loop, with the grand, open scale of the front correlating with the lower acuity areas and intimate, confined size being more suitable to the more traumatic cases.



176. Building Section through Meeting Street
2007 // Ruthven

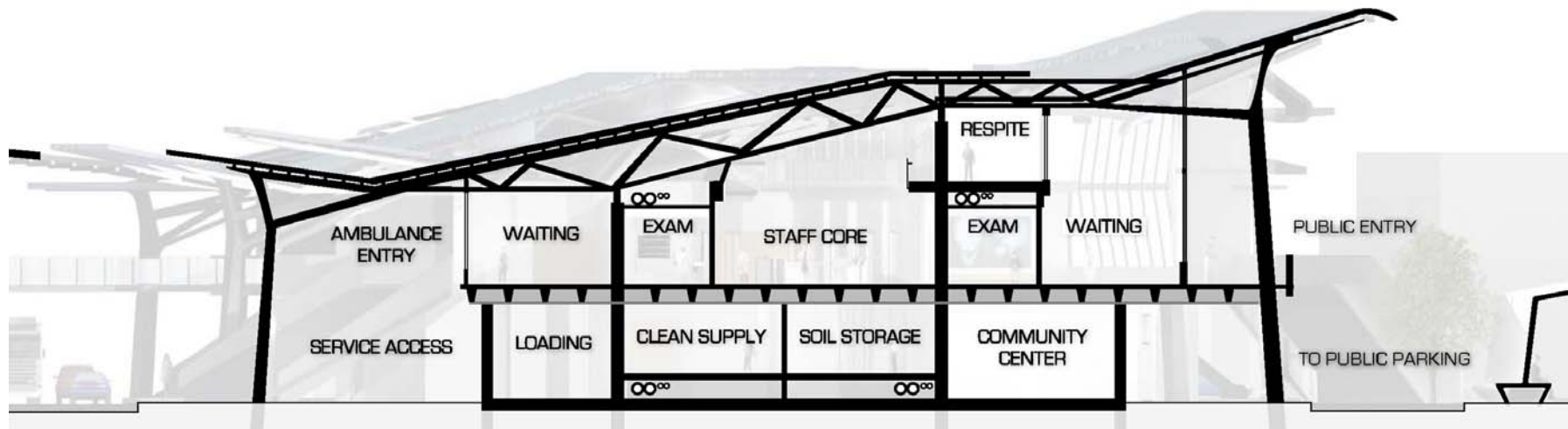


177. First Level Floor Plan
2007 // Ruthven



178. Structural Truss System
2007 // Ruthven

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].



179. Structural Section through Meeting Street
2007 // Ruthven

Focus Areas: Entry Triage, Patient Exam Room, and Staff Work Core



180. Focus Areas
2007 // Ruthven

As determined by an analysis of the throughput process, the entry triage, patient examination, and staff work core areas are critical components to the operational success of the emergency care environment. The integration of digital elements into the architectural design of these spaces advances the delivery of care by improving accessibility to digital resources, increasing spatial and systematic flexibility, and streamlining the healing environment.

Entry Triage // The entry sequence into the facility begins at the exterior site level. A concourse drop-off ramp enables vehicular traffic to move rapidly through the site, with entry off of Meeting St. and the exit opening onto the public parking area and Huger St. As the main vehicular artery serving the site, Meeting St was better suited for an entry condition, whereas Huger Street's slower traffic made it suitable for easy exiting procedures. Unfortunately, this condition resulted in the driver's side being located along the drop-off curb, a situation which was remedied by instituting a valet service at

the entry. 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 (ED patient, imaging outpatient, or visitor) to the correct area of the facility. Visibility to all major entry/exit points, vertical circulation elements, and front waiting areas enable the entry area to also act as a security station.

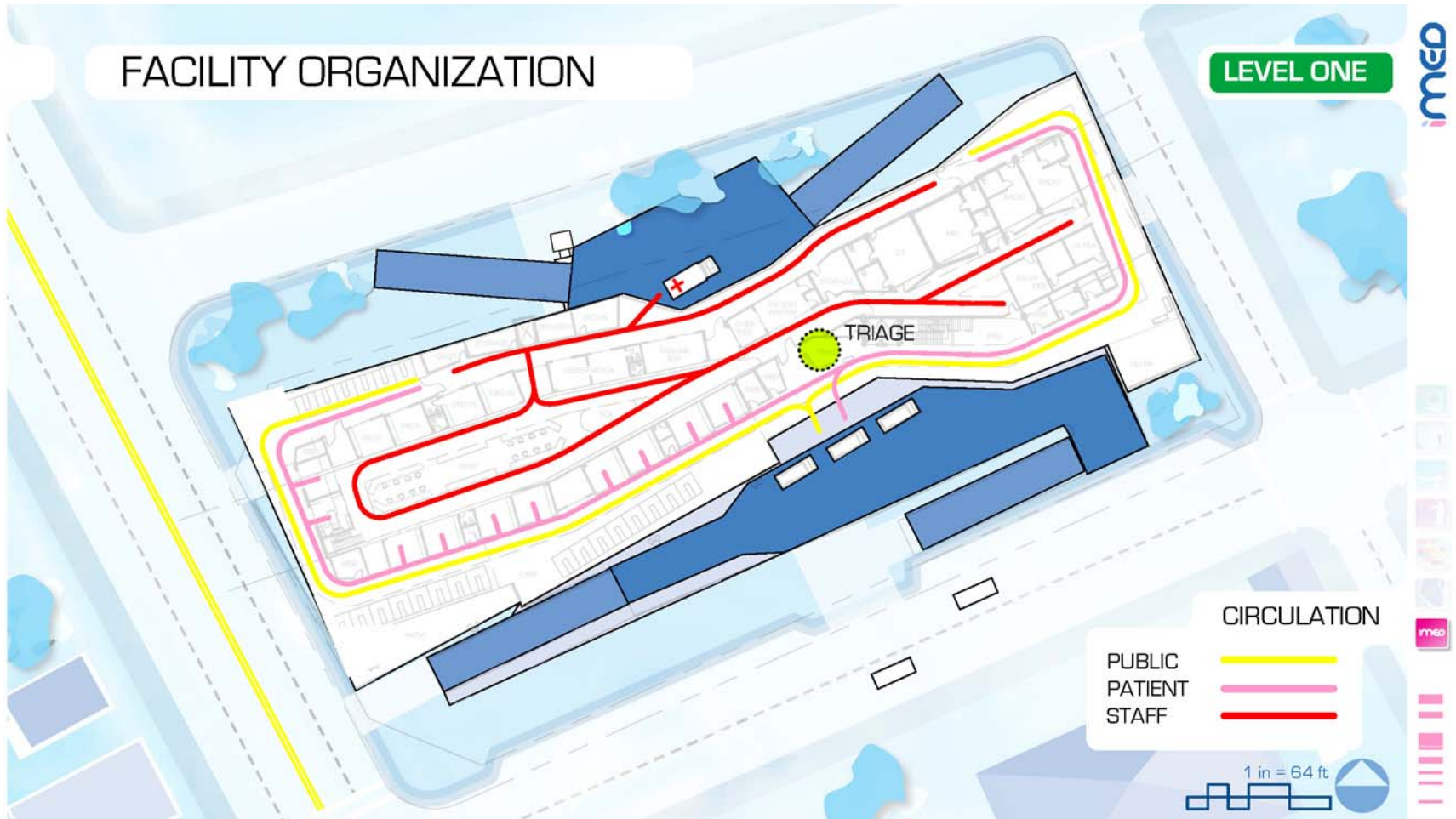


181. The Entry Triage Area
2007 // Ruthven

The layers of penetration for the facility spread out public circulation along the exterior façade, internalizing the staff work core with the patient examination space being centered between both areas [see plan on next page]. 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 information, entertainment, or internet access. Additionally, a scrolling medical alert ticker was integrated into the overhang, informing visitors of wait times and overall position in line to receive services.

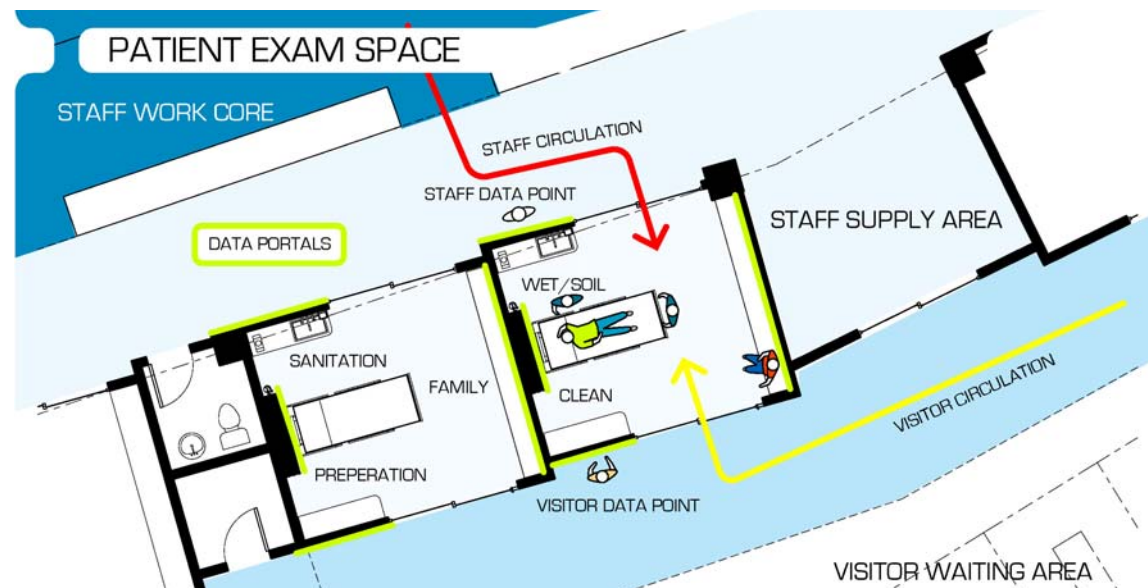


182. Clustered Waiting Area
2007 // Ruthven



183. The Layers of Penetration
2007 // Ruthven

Patient Examination Space // 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 sanitization, clean, patient, and visitor. The sanitization zone includes all wet functions within the exam room, such as the staff sink (singular molded Corian surface), soiled linen cart storage (under counter), sharps container, and hand sanitizer (in counter). The dry zone consists of a counter preparation area (which folds into the wall) and storage underneath for a mobile medical supply cart. All of the rooms in the unit are universally organized into same handed environments, further standardizing the space for efficient and effective patient care.



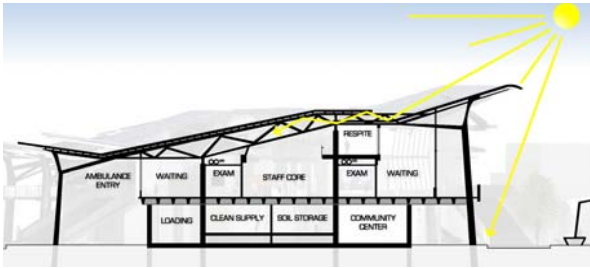
184. Floor Plan Diagram of the Patient Examination Space
2007 // Ruthven

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 headwall is one continuous piece that extends to the ceiling, offering a several lighting possibilities such as direct overhead and ambient conditions. The family footwall consists of a continuous supply bench element along its lengths, containing clean linens, blankets, and clothing. The footwall itself 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. All elements in the room are streamlined and simplified through a reduction in the number of total surface areas, improving cleanability of the environment.



185. Patient Examination Space

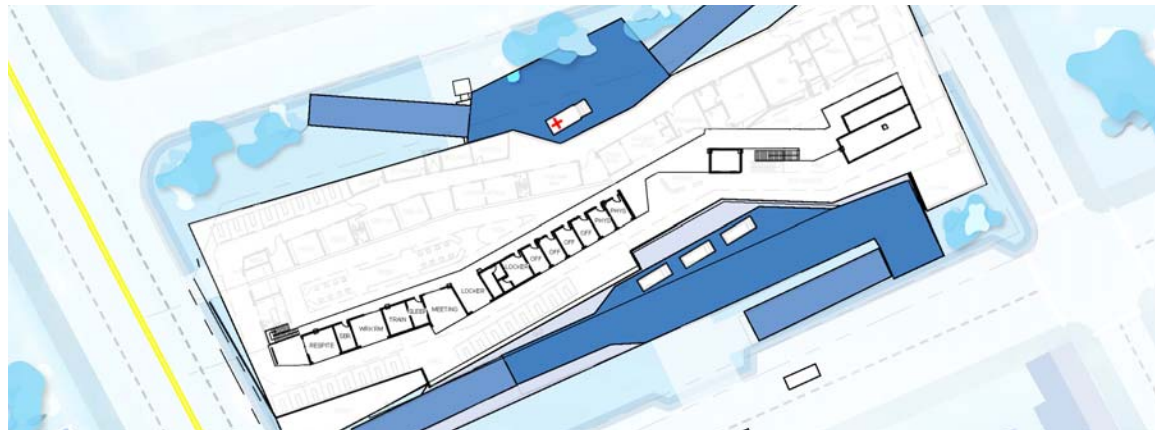
2007 // Ruthven



186. Natural Light Penetration into the Staff Core

2007 // Ruthven

Staff Work Core // 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 to move throughout the unit. Staff respite areas were elevated to a mezzanine level above the unit, enabling the overall footprint 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).



187. Mezzanine Level for Staff Respite

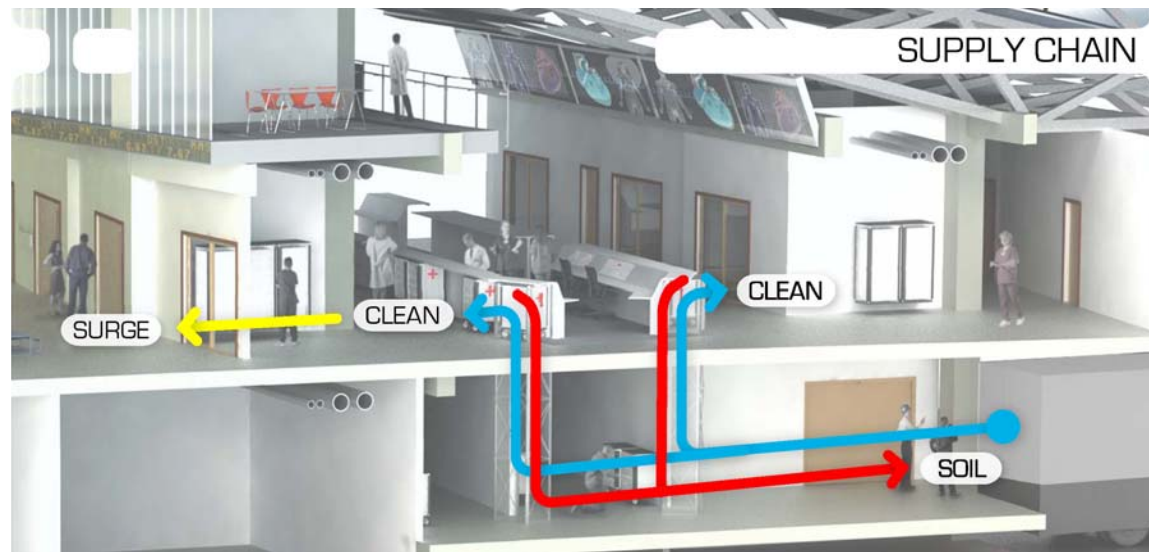
2007 // Ruthven

Digital workstations consist of integrated counter surface touch screen interfaces which can be accessed at any point along its length, enabling staff flexibility and mobility. The circulation side of the work counter features docks for mobile medical supply carts to nest, adjacent to patient care areas for easy access. Decentralized nurse stations are provided in the form of integrated digital wall elements adjacent to each care space. Collectively, nurses have a myriad of choices for possible data entry points, including the in-room digital footwall, handheld mobile PDA, decentralized station platform, or integrated workstation, optimizing their accessibility to information.



188. Staff Work Core and Mezzanine Level
2007 // Ruthven

The vertical supply system is enabled through a series of specially designed cart lifts which are located at the ends of each counter element on respective ends of the unit, providing a means for staff to dispose of used carts or deploy new ones from holding areas below. Portable wall mounted supply stations are located at the central crux of the unit, enabling their quick deployment in waiting areas and easy access in the core. This vertical supply system or “chain” minimizes the amount of spaces required in the staff core, increasing unit efficiency by allowing it to become more compact. Additionally, visibility across the unit is not compromised by the inclusion of these spaces. The storage areas below are subdivided into soiled and clean respectively, in order to eliminate any decontamination between the two.



189. Vertical Supply Chain
2007 // Ruthven

Surge Capacity: Expansion and Adaptation of Services

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.



190. An Earthquake Hits the Charleston, SC Region
2007 // Ruthven

Surge Triage // 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 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 area has been over designed in order to accommodate increased activity at this level.



191. Expanded Entry Triage Area

2007 // Ruthven

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.



192. Surge Deployment by Module Corresponding to Surge Levels
2007 // Ruthven

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.

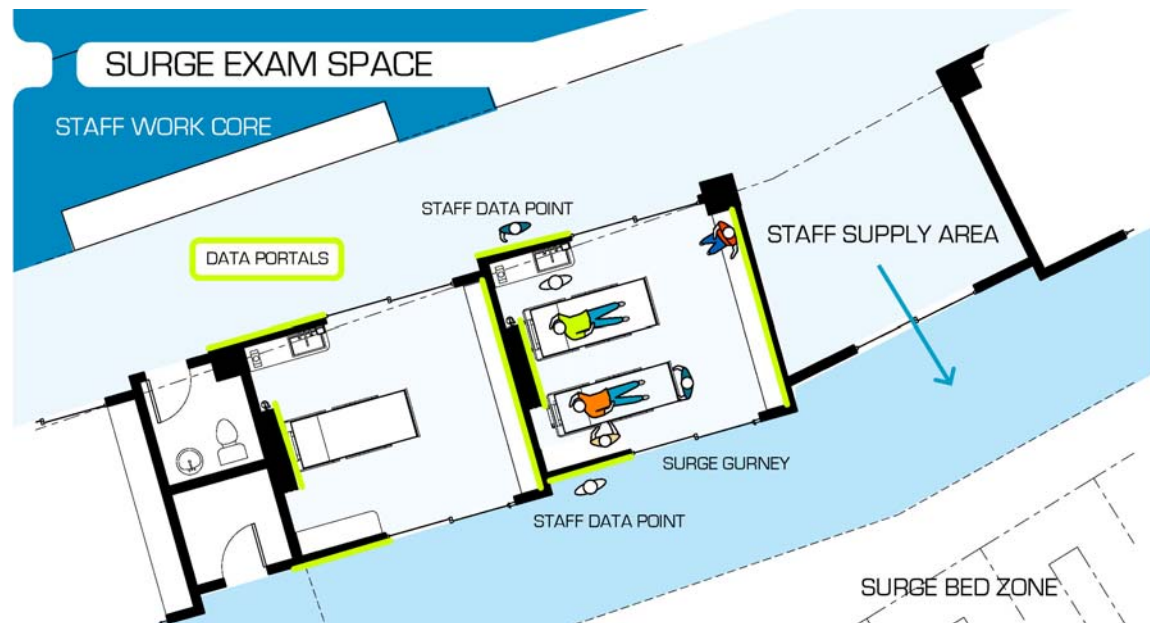


193. Surge Deployment in Waiting Areas
2007 // Ruthven



194. Expanded Patient Exam Room
2007 // Ruthven

Expanded Capacity Patient Care Area // 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 family footwall bench can be further utilized by low acuity patients who simply need a space to reside. The digital headwall is designed to include two sets of hookups, as well as digital resources to display each separate patients vitals.



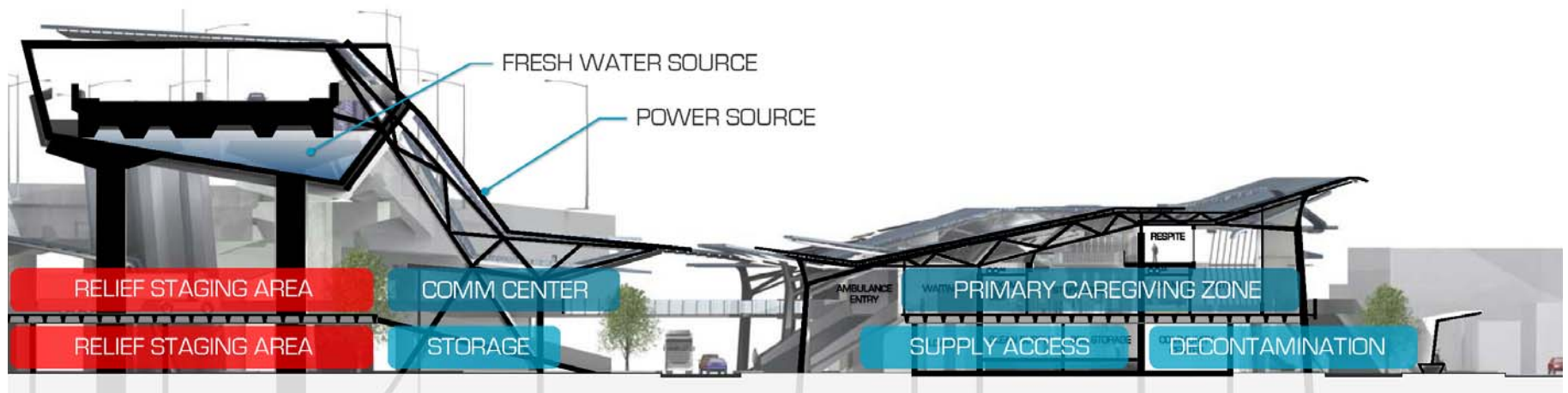
195. Expanded Patient Exam Room Plan
2007 // Ruthven

Increased Activity in Staff Work Core // 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 positioned outside of immediate view in surge converted waiting spaces.



196. Adapted Staff Work Core
2007 // Ruthven

Site Surge Adaptation and Expansion // 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.



197. Sectional Diagram of Staging Areas
2007 // Ruthven

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.



198. Site Plan with Staging and Distribution Areas
2007 // Ruthven

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.



199. Digital Transformation of Urban Elements for Surge Activity
2007 // Ruthven

FINAL CONCLUSIONS

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.

APPENDIX

HEALTH IN THE AGE OF INFORMATION

Advances in information technology have made information more readily accessible than ever before in the healthcare environment.

The architectural response to the development of IT has largely been reactive, creating spaces and systems that lack flexibility to adapt, hinder performance by limiting accessibility, and degrade the healing environment.



CONTRACTS CONSULTANTS POINT OF CARE

PHYSICAL THRESHOLD AS DIGITAL SCANNER



Buildings become less than one able to collect efficient digital forms and generate appropriate environmental responses from program strategies, increasing safety, comfort and control over the environment.

RESEARCH + DESIGN PRINCIPLES

DISCONNECT BETWEEN INFORMATION TECHNOLOGY AND THE ENVIRONMENT

The flexibility and performance of the environment are compromised by fixed position, single user data systems which prevent it from actively engaging to changing conditions.

The overall quality of the healing environment is degraded, affecting patient outcomes by negating the work habits, professionalism and speed and safety of their surroundings.



UNPREDICTABLE VOLUPTUOUS GIFTS

- FAST PACE CARE SETTINGS
- LARGE DEFICIENCY OF LUNGS
- HIGH UTILIZATION, TURNOVER PATTS

EMERGENCY CARE ENVIRONMENT

LAYERS OF PENETRATION



Regulating water penetration into the staff work area would provide several operational improvements, including decreased levels of noise contamination, reduction of staff absences, and demarcation of water crossing.

THEESIS STATEMENT

THE DIGITALLY INTEGRATED HEALTHCARE ENVIRONMENT

Resolving the disconnect between architecture and IT, which can be achieved by devising modalities that both evolve together during the design process, can create a more holistic, digitally integrated setting to deliver care.



PHYSICAL SPACE DIGITAL SYSTEM DIGITAL ENGAGEMENT

INTERACTIVE MEDICAL EMERGENCY DEPARTMENT

The emergency care department represents a suitable healthcare typology to implement the thesis because it is an environment that has unpredictable volumetric shifts, rapidly paced care delivery which is dependent on quick information utilization, and large variety of illnesses treated which require different processes.



BUILDING AS INTERFACE



In order to optimize the flow of information, access to input areas needs to be made fluid by converting the building as an interface where input and output is fluidly exchanged through digital connections.

INFORMATION TECHNOLOGY AS ENVIRONMENT

Buildings can take on new roles in society by integrating information technology (IT) into their design, rather than applying systems afterwards.

Reallocating fixed position, single user data entry systems with environmentally integrated surface interfaces would increase the amount of available platform exponentially, enabling the facility to effectively adapt to changing conditions.

The environment can be streamlined and simplified, providing the benefits of information technology while reconstituting its negative physical characteristics.



CONTEMPORARY EMERGENCY DEPARTMENTS ARE PLAGUED WITH SEVERAL SERIOUS PROBLEMS INCLUDING OVERCROWDING, STAFFING ISSUES, AND INABILITY TO EXPAND DURING SURGE EVENTS, WHICH ARE THE RESULT OF INADEQUATE THROUGHPUT METHODOLOGIES.

- OVERCROWDING/INEFFICIENT
- INCREASE IN UTILIZATION PATTS
- STAFFING INEFFICIENCIES
- DEVELOPING NUMBER ADAPTABLE FACILITIES
- SPACE QUOTE (H.E.A.L.A.P.P.I.T)

BUILDING AS SPONGE



The facility needs to be designed in order to act as a sponge absorbing and generating the right type of information or to act as a sponge expelling and generating the right type of information or to act as a sponge absorbing and generating the right type of information.

DIGITAL ARCHITECTURE

CREATING NEW LINKAGES BETWEEN ENVIRONMENT AND INHABITANT



APPROPRIATE EXISTING INFRASTRUCTURE



imeo

FREESTANDING ED TYPOLOGY

- Freestanding EDs avoid burdens associated with existing facilities (phasing, existing layouts, etc.) and are a viable option for expanding provider coverage, capturing areas with growing populations and improving their network's ability to respond during mass casualty events.

FACILITY PROGRAM

- The base program was derived from the Swedish Medical ED (Carbon Air-locks), then modified to function as a Point of Delivery (POD) facility during mass casualty events.

SCENARIO PLANNING

- In order to effectively prepare simulations to test possible responses from the facility's program, a series of planning scenarios were developed, ranging from mass casualty surge events to daily patient loads.

CHARLESTON COUNTY REGIONAL ANALYSIS

Map showing regional context with locations like SUMMERVILLE, DANIEL ISLAND, MT PLEASANT, WEST ASHLEY, N. CHARLESTON, and CHARLESTON. Includes a legend for 'TOTAL BEDS' and 'TOTAL BED-COUNT'.

CHARLESTON URBAN ANALYSIS

Map showing urban context with locations like WEST ASHLEY, CHARLESTON, and MT PLEASANT. Includes a legend for 'GROWTH ZONES' (A. MANDALA PLAN, B. OLF COURSE PLAN, C. COOPER REDEVELOPMENT) and 'FLOOD ZONES' (VE 0-3 FT, X 3-6 FT, X500 6-8 FT).

COOPER BRIDGE REDEVELOPMENT DISTRICT

Map showing the selected site location within the Cooper Bridge Redevelopment District. Includes a legend for 'CIRCULATION' (REGIONAL ARTERIAL, URBAN ARTERIAL, URBAN NEIGHBORHOOD) and 'FLOOD ZONES' (VE 0-3 FT, X 3-6 FT, X500 6-8 FT).

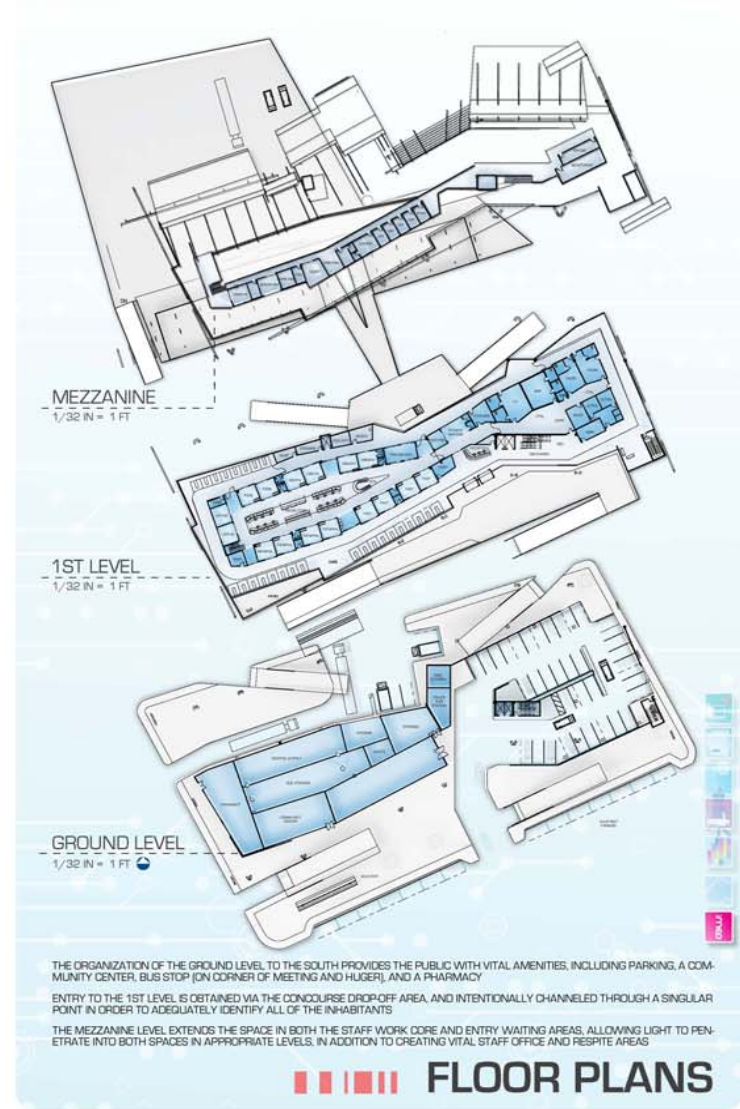
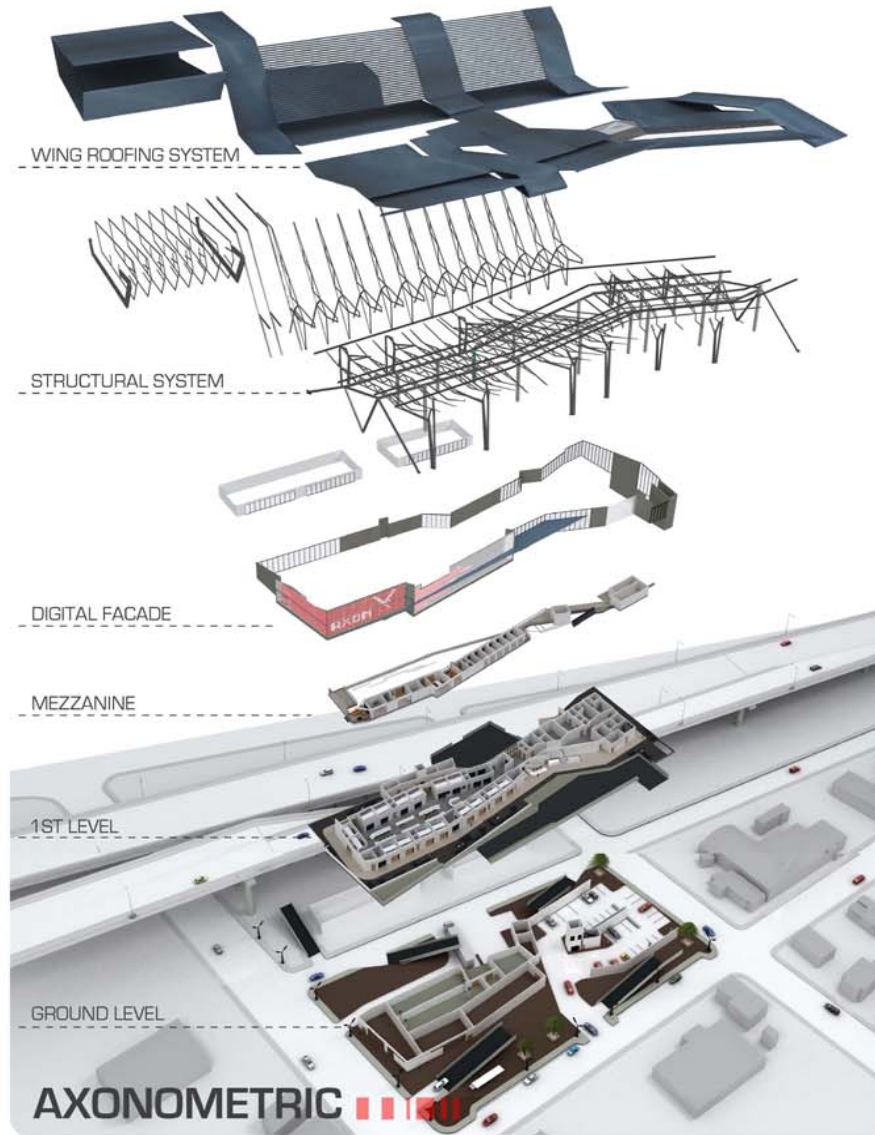
SITE CRITERIA

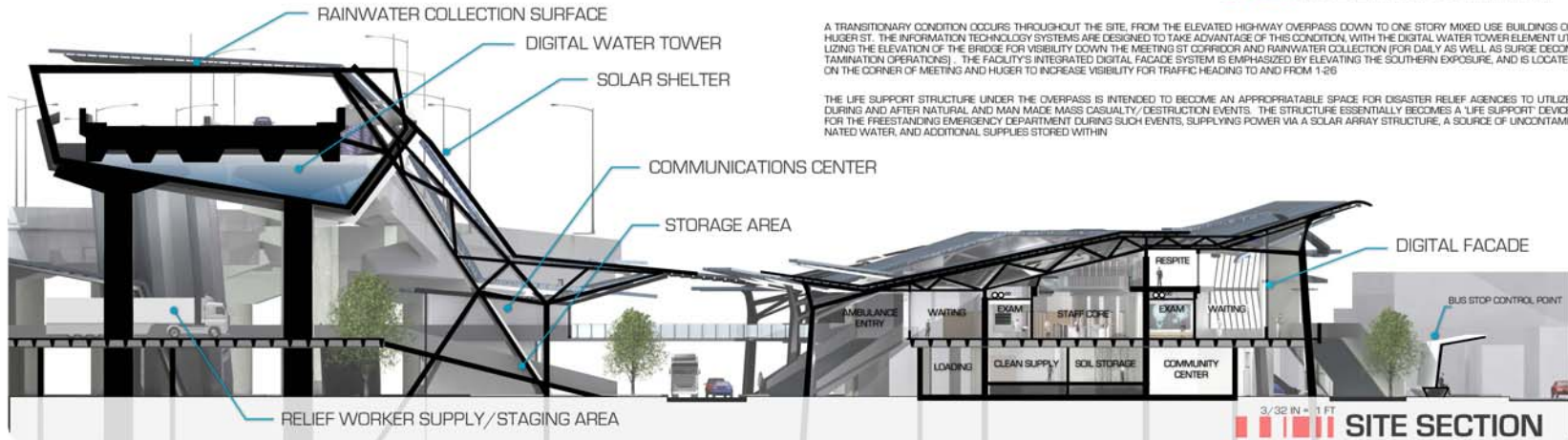
- In order for the facility to prepare for mass casualty events, it must be sited according to the following criteria:
 - Topographically, the site must be on high, stable land in order to prevent flooding and earthquake damage.
 - Adjacent access to open staging areas, fresh water supplies, food distribution centers, and appropriate utilities is critical to facility effectiveness during disasters.
 - Direct access to main regional/urban arterial circulation paths is required in order to operate + evacuate.
- The selected site lies on stable, high soil near the new Cooper River Bridge.
- Appropriation of the highway corridor as shelter enables caregivers to reuse open areas for staging purposes.
- The site has a direct connection to I95 + Rte. 17, both primary regional circulation arteries.
- Within the city, the site is linked to the primary circulation corridors of Meeting St (main NE road) and Huger St (NW road connects under I95).

PROGRAM + SITE

Final Presentation Materials: Program and Site Board
2007 // Ruthven







A TRANSITIONARY CONDITION OCCURS THROUGHOUT THE SITE, FROM THE ELEVATED HIGHWAY OVERPASS DOWN TO ONE STORY MIXED USE BUILDINGS ON HUGER ST. THE INFORMATION TECHNOLOGY SYSTEMS ARE DESIGNED TO TAKE ADVANTAGE OF THIS CONDITION, WITH THE DIGITAL WATER TOWER ELEMENT UTILIZING THE ELEVATION OF THE BRIDGE FOR VISIBILITY DOWN THE MEETING ST CORRIDOR AND RAINWATER COLLECTION (FOR DAILY AS WELL AS SURGE DECONTAMINATION OPERATIONS). THE FACILITY'S INTEGRATED DIGITAL FACADE SYSTEM IS EMPHASIZED BY ELEVATING THE SOUTHERN EXPOSURE, AND IS LOCATED ON THE CORNER OF MEETING AND HUGER TO INCREASE VISIBILITY FOR TRAFFIC HEADING TO AND FROM 1-26

THE LIFE SUPPORT STRUCTURE UNDER THE OVERPASS IS INTENDED TO BECOME AN APPROPRIATE SPACE FOR DISASTER RELIEF AGENCIES TO UTILIZE DURING AND AFTER NATURAL AND MAN MADE MASS CASUALTY/DESTRUCTION EVENTS. THE STRUCTURE ESSENTIALLY BECOMES A 'LIFE SUPPORT' DEVICE FOR THE FREESTANDING EMERGENCY DEPARTMENT DURING SUCH EVENTS, SUPPLYING POWER VIA A SOLAR ARRAY STRUCTURE, A SOURCE OF UNCONTAMINATED WATER, AND ADDITIONAL SUPPLIES STORED WITHIN



ENTRY TRIAGE ■ ■ ■ ■ ■



■ ■ ■ ■ ■ **SURGE WAITING CONVERSION**

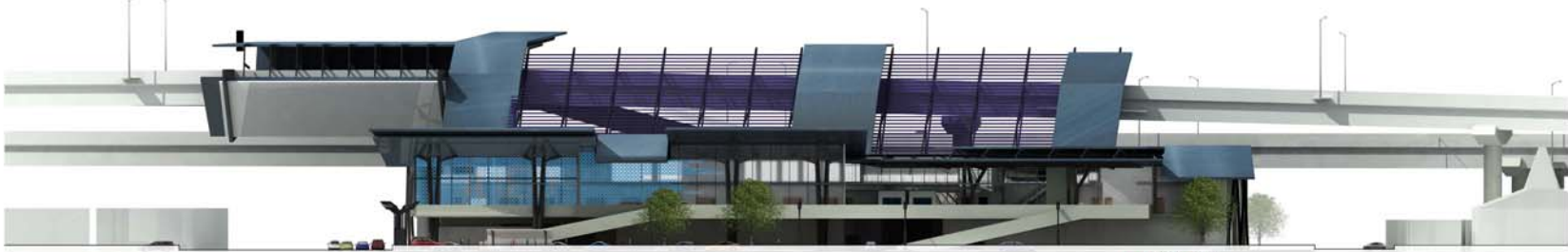


AFTER IN-HABITANTS ARE SCANNED INITIALLY AT THE FRONT DOOR, THE ENTRY TRIAGE SPACE OPENS TO A CENTRALIZED KIOSK FOR PRELIMINARY DATA ENTRY AND BIOMETRIC SCANNING TO ENABLE SYSTEMS RECOGNITION. THE ENTRY KIOSK CONTAINS MULTIPLE POINTS IN WHICH TO ENTER THE SYSTEM IN ORDER TO ACCOMMODATE SURGE TRIAGE PROCEDURES. ADDITIONAL WALL SURFACES THROUGHOUT THE ENTRY AND WAITING AREAS CAN BE UTILIZED TO CONDUCT TRIAGE PROCEDURES DURING ADVERSE SURGE EVENTS.

THE WAITING AREAS CONTAIN DEPLOYMENT SUPPLIES WITHIN THE BASE OF THE FACADE (JURNEY, MEDS, HEADWALL GASES). THE MOBILE FURNITURE SYSTEMS CAN BE QUICKLY MOVED TO CLUTTER CORNERS LOCATED THROUGHOUT THE SPACE. A FAMILY DIGITAL ACCESS WALL POINT IS LOCATED ADJACENT TO THE PATIENT EXAMINATION ROOM, AND CAN BE CONVERTED FOR USE AS A DECENTRALIZED NURSING STATION WHEN SURGE BEDS ARE DEPLOYED IN THE AREA.

EACH SAME HANDED PATIENT EXAMINATION ROOM FEATURES DIGITAL ELEMENTS INTEGRATED INTO THE FAMILY FOOTWALL AND HEADWALL COMPONENTS, DISPLAYING PATIENT VITALS, MEDICAL INFORMATION, AND ENTERTAINMENT. DURING SURGE EVENTS, THE CLEAN SUPPLY AREA FOLDS AWAY IN ORDER TO PROVIDE SPACE FOR AN ADDITIONAL GURNEY TO BE SETUP IN THE SPACE, AND WITH AN EXPANDABLE FOOTWALL BED BENCH CAN TRIPLE THE ROOM'S OCCUPANCY.

THE STAFF WORK CORE IS ORGANIZED INTO A COMPACT ARRANGEMENT WHICH ENABLES IT TO FUNCTION EFFICIENTLY, AND IS A DIRECT RESULT OF INTEGRATING SYSTEMS INTO THE ENVIRONMENT AND MOVING SUPPLY AREAS WHICH ARE TYPICALLY LOCATED MID-UNIT IN A SERVICE AREA BELOW. THE CORE FEATURES A MULTITUDE OF DATA POINTS WHICH CAN BE ACTIVATED BY A LARGE QUANTITY OF USERS, ENABLING IT TO FUNCTION EFFECTIVELY DURING PERIODS OF STAFF INCREASES.



1/16 IN = 1 FT **HUGER ST ELEVATION**



SECTION MODEL

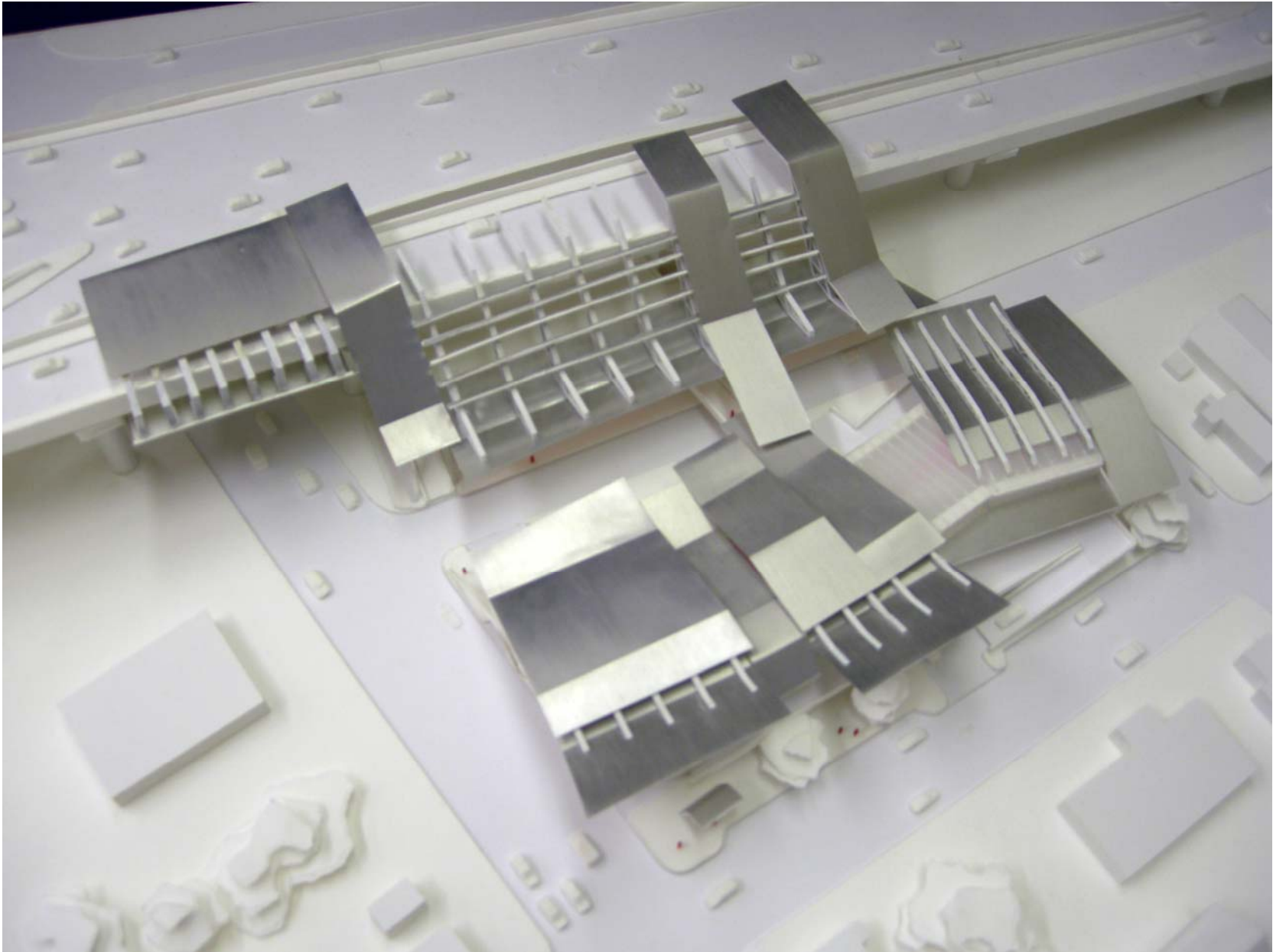
THE VERTICAL SUPPLY CHAIN ALLOWS THE FACILITY TO REMAIN COMPACT, MOVING SUPPORT SPACE BELOW AND MINIMIZING THE FOOTPRINT OF THE STAFF WORK CORE ABOVE. THE SUPPLY AREA IS DIVIDED INTO TWO DISTINCT ZONES, FOR CLEAN AND SOILED SUPPLIES RESPECTIVELY. ALL SUPPLIES ARE LOADED ONTO CART COMPONENTS THAT ARE ABLE TO DOCK IN THE CENTRAL NURSE STATION ABOVE. STAFF CAN QUICKLY SEND SOILED UNITS DOWN FOR PROCESSING, OR ORDER FRESH SUPPLIES WHEN NEEDED FOR DATA POINTS WITHIN THE BUILDING.



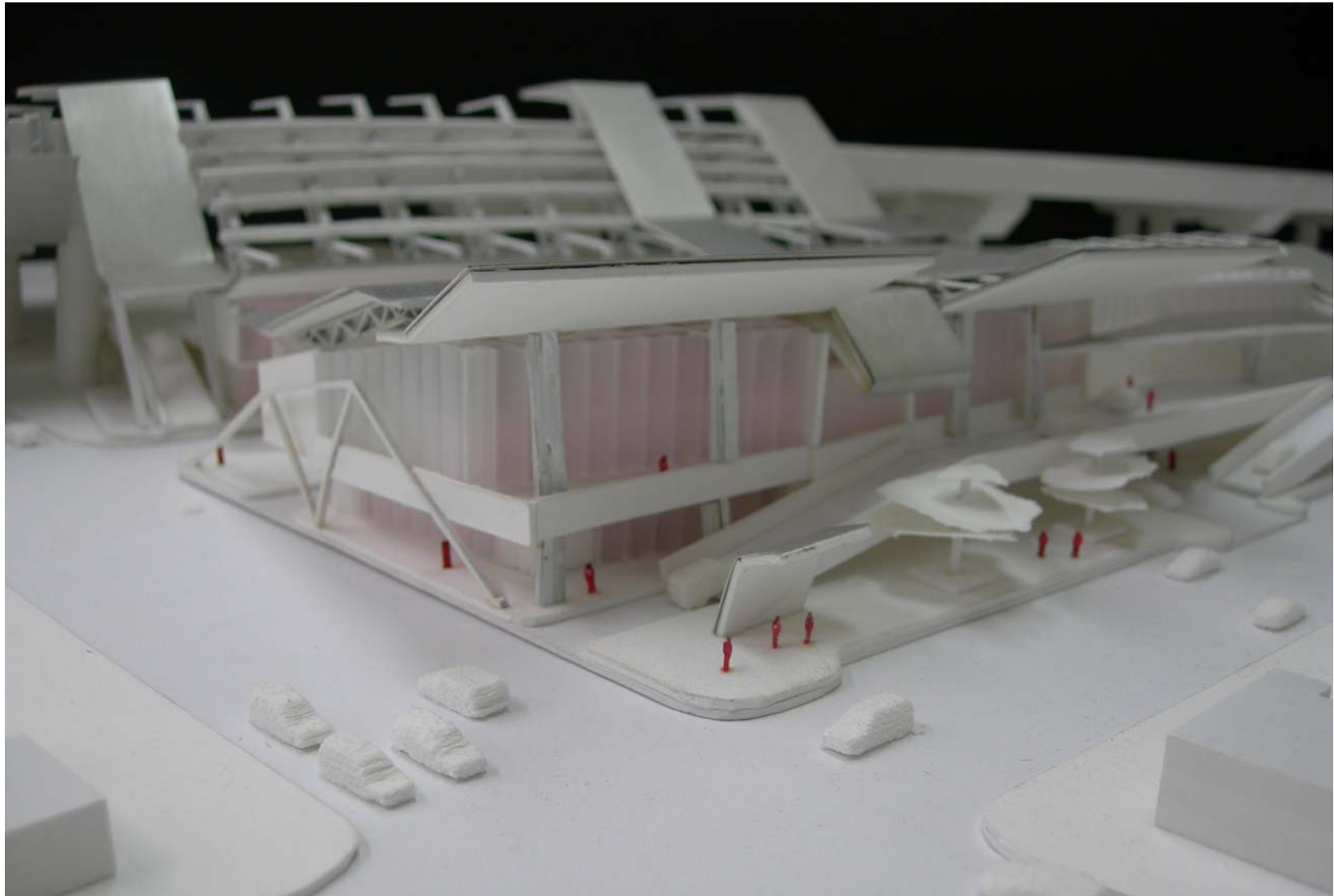
EXPANDED PATIENT EXAM SPACE



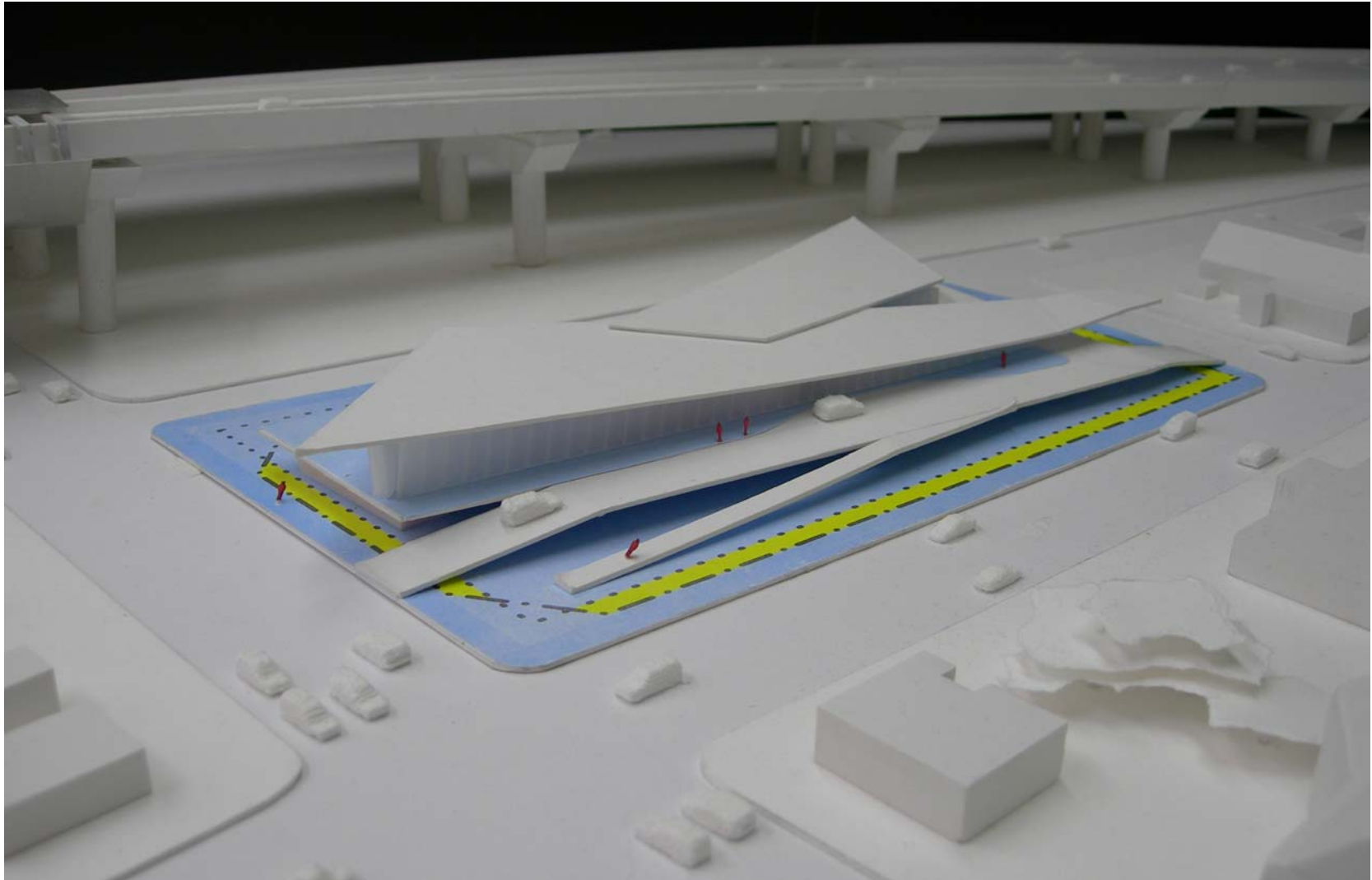
STAFF WORK CORE



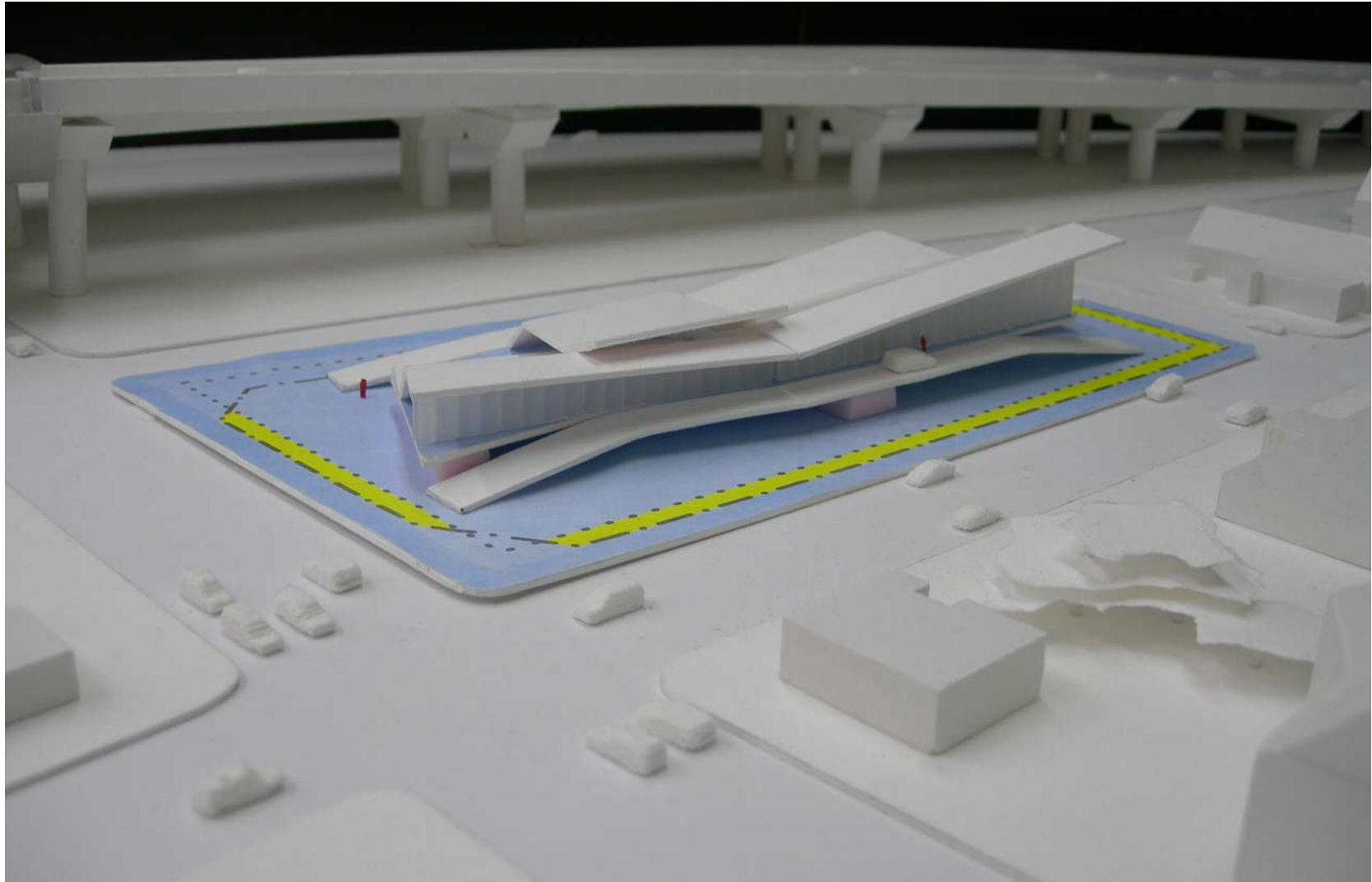
Final Project Model
2007 // Ruthven



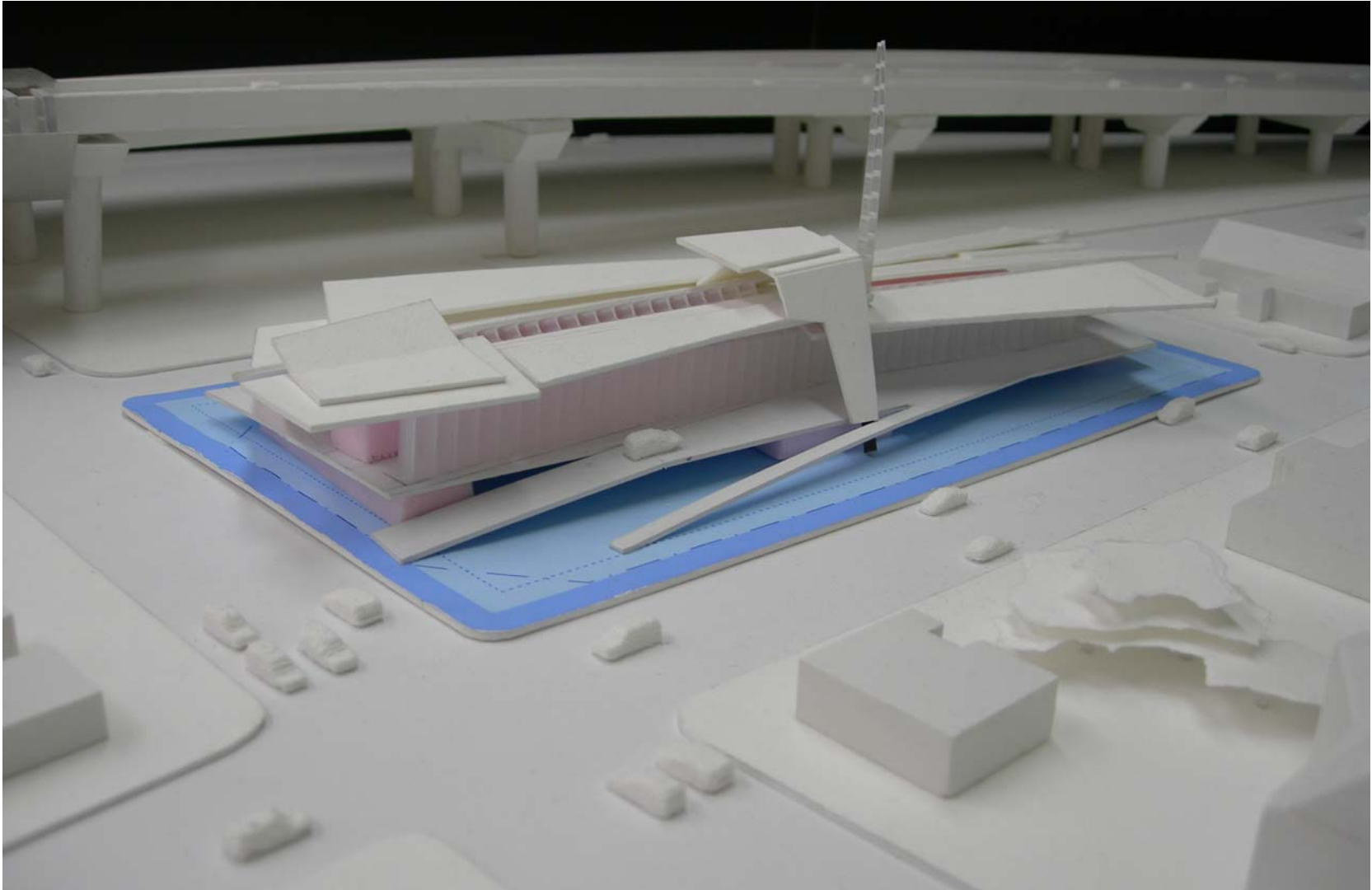
Final Project Model
2007 // Ruthven



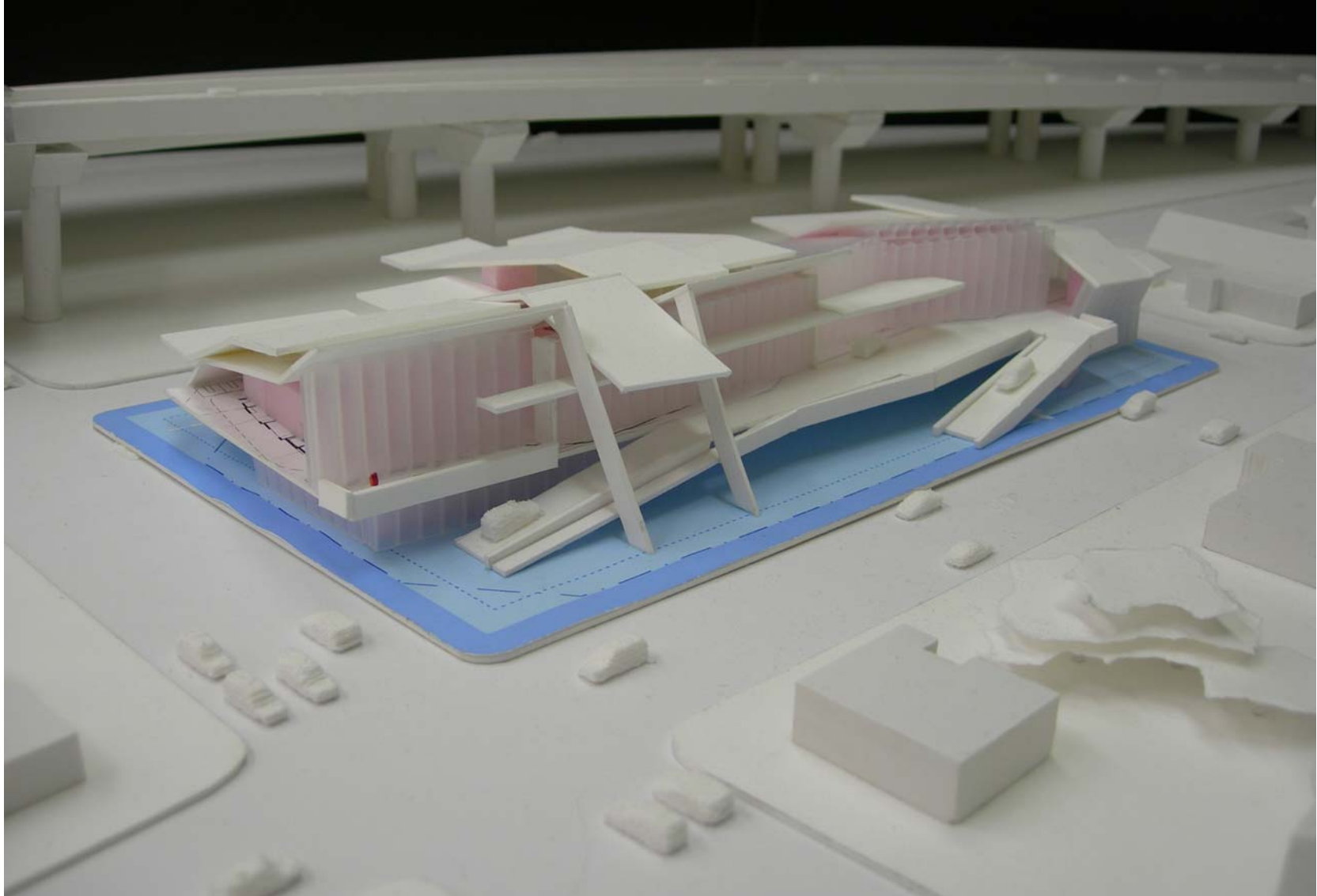
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2007 // Ruthven



Project Parti Model 02
2007 // Ruthven



Project Parti Model 03
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Project Parti Model 04
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