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Antibody Architecture: Responding to Bioterrorism

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ANTIBODY ARCHITECTURE

Responding to Bioterrorism

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

Heather Marie Voorhaar

May 2009

ABSTRACT

Bioterrorism, the use of biological and chemical agents for terrorist purposes, is one of the most potentially significant health and security threats currently facing the United States. Healthcare facilities as isolated entities are alone unable to provide sufficient, adaptable emergency response options during a bioterrorist attack—an unpredictable, low probability, high consequence event. Bioterrorism response must be systemic, distributed, flexible, and responsive for a wide range of event incidents, scenarios and contexts. A significant problem yet to be adequately addressed is the mitigation of the walking well—those who are not sick or injured but have the potential to inundate any designated response setting.

Architectural interventions alone are limited in their ability to provide an appropriate response to an act of bioterrorism. An analogy to the human immune system and how it operates in the body to overcome pathogens will be used to articulate a systematic bioterrorism response and a series of architectural interventions for dealing with the walking well. Similar to our immune system, a response network (or system) should be created that operates throughout high risk urban contexts and takes advantage of existing architectural settings in order to deploy as needed and where needed in response

to a bioterrorist attack. An antibody response to bioterrorism must be able to adapt to meeting the needs of various scenarios and contexts in which an incident might occur. Drawing on this biological metaphor, any proposed architectural interventions must include latent capabilities while having the ability to be activated in place and scalable in order to accommodate the multiple potential threats and the many variables inherent with bioterrorism.

The proposal for an architectural response to bioterrorism is situated in Washington, D.C., identified as the highest potential target city in the United States for acts of bioterrorism. Appropriate latent resources capable of acting as a part of the response network throughout the D.C. urban context will be identified and their potential activation will be explored through two example scenarios, which will be used to illustrate the proposed model for systematic response. The most architecturally significant locations for (activated) small scale interjections will be designed to meet the first response needs of the general population who would be moving about in the city during the detection of an event. These sites and features will allow for differing degrees of self-diagnosis during and following an event as well as provide general day to day and event related

public health information. The proposed architectural interjections will be designed to respond to the predicted fear and panic exhibited by the walking well during a bioterrorist attack, and minimize their potential for overwhelming hospitals and other healthcare settings in the target region.

DEDICATION

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INTRODUCTION

Bioterrorism, the use of biological and chemical agents for terrorist purposes, is one of the most potentially significant health and security threats currently facing the United States. Bioterrorism is an unpredictable, low probability, high consequence event. Any response, including architectural settings for diagnosis and treatment must be systemic, dispersed, adaptable, and reactive to a wide range of event variables. This thesis focuses on a systematic response and specific architectural interventions for a significant yet substantially unaddressed population that would present themselves in great numbers upon available response settings and services—the walking well, those who are not sick or injured, but result as a manifestation of panic. This population has the potential to cripple existing healthcare response services that would otherwise adequately handle most scenarios.

The original intent of this thesis was to establish an architectural model that provides a kit of parts with adaptable, modular and mobile capabilities designed to accommodate a range of episodic incidents, scenarios and contexts. However, architectural interventions alone are limited in their ability to provide an appropriate response to an act of bioterrorism. The low probability, high consequence nature of an event of

bioterrorism requires that an architectural and systemic response should provide both latent and activated programmatic functions. A response to bioterrorism must be able to provide a response throughout an urban or regional threat context that is flexible and responsive for a range of event variables.

Throughout this thesis several terms will be used to define the nature of a bioterrorist event—incident, scenario and context. Incident refers to the type of agent, either chemical or biological, dispersed throughout an urban threat context. Scenario defines the way in which an incident occurs—within a building or an exterior context, and the number of people that might be impacted. Context establishes the range of location(s) in which the response will take place. These terms will frame the conditions used to define probable scenarios of bioterrorist attack.

The Threat of Terrorism: On September 11, 2001, the reality of a terrorist attack was made known to Americans. Since then, high risk environments have been defined, putting Washington, D.C. at the highest risk for attack. This thesis will focus on a response proposal based in Washington, D.C. Despite the awareness of vulnerabilities

within the United States post-September 11, significant gaps still lie between emergency responders and healthcare facilities, therefore presenting the challenge of providing a sufficient response for higher probability locations, and especially acts of bioterrorism.

The nature of bioterrorism is that in any given location there is a relative low probability of an event occurring, yet there is a high consequence of not being prepared. The unpredictable nature of bioterrorism in terms of timing, location and scope remains the greatest challenge to healthcare facilities and emergency responders. This unpredictability hinders the ability of healthcare facility planning and preparedness. As a result, two models of an architectural response can occur—highly specialized centralized locations, and decentralized models of response throughout densely populated urban contexts.

Despite the unpredictable nature of bioterrorism, models of response are being developed with highly specialized and centralized response facilities. During an event, centralized settings are specifically designed to respond to terrorist events and other disasters but

have the potential to be remote and inconveniently located from the event epicenter and unable to provide an adequate response alone. During an event all patient flow will be directed to these central locations—establishing a great potential for quickly reaching capacity. An example of a centralized model is ER One, currently being implemented in Washington, D.C. ER One is an excellent response site if an event occurs in a location and way that can benefit from its resources. However, specialized models such as ER One are expensive and unfeasible to replicate in sufficient numbers and locations to adequately respond to the range of potential locations and populations that may become targets of bioterrorism. Although the concepts and intentions of the ER One project have been designed to respond to a great number of variables generated during a bioterrorist event, this type of setting is economically difficult to replicate at more than one location within an urban threat context.

As a supplement to centralized response settings, decentralized emergency response options throughout an urban context have a greater potential to serve as first response settings given the unpredictable locations of a bioterrorist attack and the real and perceived health needs of the general population, impacted by the event. A decentralized model of

response must be low cost, widely dispersed, accessible to all types of victims, versatile and activated similar to the deployment of oxygen masks on an airplane. A response capability is always present in a latent form. Once an event occurs a dispersed response can be activated providing more immediate care to a larger number of people within a response context. A dispersed response capability located frequently throughout a context therefore must be relatively inexpensive to implement, and must be able to serve a wide range of potentially impacted populations.

An act of bioterrorism would potentially place a great burden on emergency response, including healthcare facilities and other medical settings such as clinics, to respond effectively and efficiently throughout the timeline of an event. The most considerable issue to be addressed in bioterrorism is the capacity of a medical response to handle the unpredictability of patient flow: how many people will be impacted, where they will present for care, and the rate at which they will arrive and need care.

Where patients will go during and following a bioterrorist attack is unpredictable in regards to the number of victims generated, and where they will seek care. Both critical

and non-critical victims will be produced by an event along with the greatest number of people who will present at an identified response site—the walking well. Literature reviews, first hand research and interviews with experts from the Centers for Disease Control (CDC), the National Institutes of Health (NIH), ER One, and other healthcare facilities in the midst of preparing for bioterrorism, was conducted as a part of this thesis investigation. This research established the limits of existing strategies, identified gaps in response capabilities and established that architectural interjections alone located within healthcare facilities would not address the most significant problem--the walking well. Most healthcare facilities are generally capable of handling the demands of critical victims during a bioterrorist attack. Even the most advanced healthcare facilities are simply not able to deal with the potential total number of victims who may present themselves at any given location when the non-critical and walking well are included.

In order to allow the healthcare system and emergency responders to function, the walking well must be identified and their needs addressed away from healthcare facilities so that these settings can actually focus on treating victims with clinical

treatment needs. Planning and response efforts should take into account the walking well. Any response plan should aim to alleviate fear and panic by quickly providing the general public with opportunities to determine their risk of exposure through information and self diagnosis. A response dispersed throughout high risk contexts must present multiple opportunities for people to determine the status of their health. Providing the public with opportunities to gain a sense of control through information, their interaction with an informative architectural response site or intervention of some sort during an unfamiliar event can help ease the inevitable element of fear and panic.

Probable Factors: Potential bioterrorist attacks include a range of probable incidents. Typologies of incidents include the release of biological agents, the dispersal of chemical agents (typically in the form of a bomb) or the dispersion of radiation through a radiological device. This thesis will focus on two example incidents—one chemical and one biological. These two typologies are the most predicted and most obtainable by terrorists. Each agent, chemical or biological, requires an inherently differing means of response.

Due to their ability to produce a more evident and instant impact, chemical agents are weapons of immediacy. Immediately upon the release of a chemical agent, patients will show obvious signs of exposure and will be in immediate need of treatment within close proximity to the epicenter. An architectural response to a chemical attack must be able to react to the immediate needs in a relatively concentrated area around the event site.

Biological agents incubate within their victims often long before their presence is known, making them weapons of delayed impact. Due to the transient nature of our culture, many people work and commute within a metro area often utilizing highly populated mass transit systems. A response to a biological event will unfold over a longer period of time in a much more dispersed area because of this cultural pattern, but may involve equal or greater number of patients than a chemical attack. An architectural and systemic response must take into account multiple variables presented within chemical and biological events. Bioterrorism is unpredictable; the agent that will be used can not be predicted. Preparing for a bioterrorist attack demands the need for a ready response for all types of incidents.

Bioterrorism can be executed through many probable scenarios during an attack. During an event, it is impossible to accurately predict all potential sites for the release of chemical or biological agents, and it can be assumed that no building or location is immune against the threat of an attack. Any architectural or systemic response to bioterrorism must take into account this unpredictability and therefore be widely dispersed throughout high risk contexts.

Existing high risk event contexts are simply not capable of sufficiently responding to the potential range of conditions associated with a bioterrorist event. Healthcare facilities as isolated response centers are not prepared to handle the delivery of care to all potential patients that might present at any one emergency department during a bioterrorist attack. At the same time, existing emergency responders are not prepared to handle all the variables related to a bioterrorist attack. In order for a sufficient response to occur, healthcare facilities and emergency responders need to be systematically integrated and coordinated in their efforts.

Metaphorical Reference: Throughout this thesis, a metaphorical reference to biology will be used to conceptualize an architectural and systemic response network with latent and activated elements. An architectural and systemic response based on the principles of our immune system form the basis for the design of the proposed response concepts. The antibody system is comprised of several types of components, always present within our system, monitoring the condition of pathogenic entrance and attack. During a response to a pathogen, the human immune system responds in a systemic, dispersed manner in order to prevent pathogens from further infecting the body. A systemic architectural response must be created that establishes a network of existing locations throughout an urban context, programmed to respond based on a wide variety of potential needs and the demands of the many possible locations, events, and types and number of patients generated. A response network must be integrated and include both healthcare facilities (where critical patients can be treated) and alternative care locations (where emergent and non-critical patients can be served.) This network must allow the dispersion of a response within an activated network—transit nodes and iconographic locations dispersed throughout a threat region that people are familiar with and capable of locating and accessing during a response.

Architectural Intervention Criteria: Interventions must be designed to address the characteristics of low probability, high consequence, and unpredictable terrorism related events. Response sites and features should compliment existing resources including healthcare facilities and should be widely dispersed throughout high risk, highly populated areas. In order to be widely dispersed and located effectively across large regions they should be low cost and have latent capabilities that allow them to be of some use under non-threat conditions. These interventions should response to the following design criteria:

Integrated Technology: Integrated information technology should be included to provide the capability of notifying the public and providing continuous information during a response to a bioterrorist event. This type of systemic response should allow mobilized teams, comprised of medical staff, first responders and emergency response officials, the ability to communicate and monitor activated interventions throughout and urban context. Architectural interventions that incorporate integrated technology would be capable of being activated (through a remote hierarchical network control center) after an event has occurred and a response is necessary. Latently, integrated technology

would enable architectural interventions the ability to display pertinent public health information (controlled by integrated technology.)

Didactic Awareness: Response sites and interventions should possess an iconographic awareness similar to established means of emergency response (i.e. fire alarms distributed throughout a building) so that public knows a threat is eminent or underway and that they need to take appropriate action. Didactic architecture is an informative model of architecture and an integrated part of the everyday which establishes an awareness of response. During an event it is difficult to predict how the public will react, however it is understood that the public will respond in a more effective manner if there is a sense of familiarity with the location and use cues of the response feature.

Dynamic Response: A dynamic architectural intervention must be responsive to spatial and strategic challenges presented during a bioterrorist attack. The unpredictability of event location and patient flow demand that architectural and systemic features be capable of responding in an effective and timely manner. Dispersing programmed interventions systematically throughout a threat context establishes the ability to respond

appropriately to the unpredictable nature of an event. A response to bioterrorism should be capable of being activated based on the dynamic flow of patients over the life of an event.

Response Program: A programmatic response will include the following elements: Network control center , Public Health Information, Self Triage, and Wayfinding. Architectural response program components must take into consideration that existing healthcare networks can account for the care of critical patients—therefore the proposed programmatic components do not need to include functions that are already in place within a healthcare facility or emergency response system. For example, National Metropolitan Response Team (NMRT), a highly specialized response team located within the Washington D.C. area is already established to address decontamination during a bioterrorist event. The programmatic response of this thesis will deal immediately with the walking well and potentially infected patients at a dispersed level throughout an urban context.

Network Control Center : The network control center is the integration of existing response systems and proposed architectural interventions to bioterrorism; ultimately it is a non-architectural connection between designed interventions and emergency responders that provides continuity during the timeline of a bioterrorist event. During a response effort it is imperative that first responders communicate internally so that efforts aren't duplicated and care is distributed based on patient flow. The proposed network control center would exceed the current ability of emergency responders—for example 911 (emergency) dispatch, by integrating more typologies of response (public health, law enforcement, etc) that would have the ability to activate dispersed response interventions throughout a threat context. A network control center would allow primary responders to monitor post event factors such as the dispersion of an agent as well as growth and presentation of victims impacted by an event. The implementation of a network control center (through the use of integrated technology) is an integral part of responding to bioterrorism that would ultimately facilitate the unification of responders in a centralized location outside of the threat context, with the ability to activate dispersed, decentralized responses throughout the timeline of an event.

Public Health Information: Public health information would be conveyed through an architectural intervention integrated into the fabric of an urban context that provides the largest number of predicted patients, the walking well, with pertinent healthcare/event related information. During the response to an event, information should be conveyed to the public from one reliable source—the proposed network control center . Current sources, such as the media often provide conflicting, dramatized reactions to current events. The network control center would determine information that would need to be shared with the public through architectural interventions. Latently, information displays located at transit stops, nodes and along routes of travel would provide event related public health information and be capable of providing information on a daily basis relative to current health trends.

Self-Triage: The walking well should be mitigated from care locations by providing opportunities for self triage throughout the urban context. Self triage would alleviate emergency responders from having to directly care for the walking well therefore allowing them to focus on critical patients. This form of response doesn't currently exist, with the exception of a telephone triage; the proposed system would be more

dispersed and obtainable by a broader patient population during an event than the current telephone triage would allow. A self-triage system would provide potential patients with a series of questions assessing health conditions and determining their health status and where they should seek care (if needed.)

Wayfinding: Wayfinding is the element of the programmatic response to bioterrorism that provides patients, once they have received their diagnosis through the self triage system, the ability to navigate throughout a context (which may seem unfamiliar) to appropriate places to receive care. Wayfinding would not only provide victims with literal directions, but would also allow responders and health officials to dictate the flow of victims throughout a context by guiding them through areas which are safe from the epicenter and more importantly distributing patients to alternative care locations. Wayfinding establishes the ability to dictate the flow of victims to specific alternative healthcare facilities; once a facility reaches capacity, patients would be directed to other locations. Providing wayfinding to patients through an architectural intervention (as a result of self-triage) would alleviate the demands placed on emergency responders to provide direction to the patient population during an event—particularly the walking well.

Response Criteria: An architectural and systemic response to bioterrorism must have some measure of its ability to respond during an attack. Throughout this thesis, several federally tested exercises were studied to determine their ability to test an architectural and systemic response to the fullest degree. (Inglesby, 441) All variables should be considered in terms of their likelihood as well as the range of variable conditions that they present. Exercises exhibiting the most significant variables have the potential to place the highest degree of stress on existing response contexts, therefore presenting the greatest opportunity to test a systemic architectural response. These exercises established the timeline for which architectural interventions proposed in this thesis would come into play as well as the framework for a systemic response throughout an urban context.

This thesis proposal for a response to bioterrorism will be located primarily at a dispersed level throughout an existing mass transit system—the Metro system within Washington DC. Specific architectural interventions will take into consideration existing components within the metro system to be utilized in establishing a response to bioterrorism. In addition, the urban infrastructure of Washington DC will be utilized

to establish a dispersed, response network of alternative care location—existing non-healthcare facilities that can be converted to care settings during an event. Two typologies of events and the timelines that follow have been chosen specific to the variables of chemical and biological incidents in order to examine the full capability of the proposed response. One event will explore the immediacy of a chemical attack with an epicenter located at the heart of tourism—the National Mall. This event is smaller in scale, and the patient population is almost immediately recognizable post release of the agent. The second event investigates the timeline following the release of a biological agent. This event encapsulates a broader epicenter and a larger exposed patient population, over a greater time period. The two typologies of events chosen are different in nature, scope and scale, however both will test the capability of a proposed response (and architectural interventions) to a bioterrorist event.

BIOTERRORISM: INFECTING OUR SOCIETY

Bioterrorism Defined

Bioterrorism, the use of biological and chemical agents for terrorist purposes, is one of the most potentially significant health and security realities currently facing the United States. A strategic challenge of planning for a bioterrorist attack is that it is an unpredictable, low probability, high consequence event. “Although a terrorist attack is a low probability event for a single city or town, experts concur that it is not a matter of if or where, but when” (Waeckerle, 254). A bioterrorist event has the potential to impact a large number of people including the walking well. A response to bioterrorism must be dispersed throughout an urban context and responsive to a wide range of event variables in order to lessen the potential burden of the walking well.

Event Variables: A bioterrorism event has many variables including a range of incidents, scenarios and contexts that need to be considered when designing response strategies, tactics, resources and architectural features. An event is comprised of the previously mentioned variables; their combined impact will be unpredictable therefore leaving the outcome of an event indeterminable. The overall study and scenario planning for an event must consider all three response variables and how they react with respect to each other during the timeline of a bioterrorist attack.

Incident refers directly to the type of agent dispersed—in this thesis, chemical and biological events will be studied to understand the impact that their respective variables have on both architectural and system-wide responses. According to studies, “the perceived threat of chemical or biological weapons directed against the (U.S.) civilian population has increased substantially” (Macintyre, 242). Variables of each typology of incident takes into account the onset of an agent, the primary delivery of care and treatment needed, as well as the ways in which an agent may or may not be spread through (human) contact.

Scenario refers to the nature, scope and location of an attack including both the physical location and the impacted population. Generally, a scenario can unfold either interior or exterior to a building or transportation system. Also to be considered are the people (or victims) affected—large, small or medium concentrations or dispersions of people and agents.

Once an event has taken place, a response context refers to the locations where the incident and its resulting response occur and where the delivery of care takes place.



Figure 1, NYC, September 11

Treatment for critical victims can be established at one or more healthcare facilities and/or at the incident epicenter during instances in which trauma has occurred and it is best not to transport patients. Treatment of non-critical patients can be administered at alternative care locations. Dispersed responses throughout an urban context will primarily assist unsuspecting victims whose symptoms have not yet presented and the walking well, those who may fear they have been exposed but again present no symptoms.



Figure 2, NYC, September 11

September 11, 2001: Facing an unexpected act of terrorism, the American population was awakened to the reality of a man-made-disaster during the attacks in both New York City and Washington, D.C. on September 11, 2001 (Figure 1 & 2). This terrorist attack had a fierce impact on our Nation, and as a result “brought into focus the fragile state of the nation’s acute healthcare system” (Hanfling, 128). However, “more than two years after the unprecedented attacks on the United States the nation’s level of capability for large-scale emergencies remains suboptimal” (Hanfling, 128). Many healthcare facilities and emergency responders have begun to strategically plan response strategies to bioterrorism, however a great number remain unprepared. Safeguarding

the United States as a whole can be considered a challenge in part “because of its size and scope, the nations’ critical infrastructure is hard to protect; then again terrorists have historically not attacked it, preferring instead to go after targets offering high symbolic value or killing fields” (Jenkins, 3).

According to the *September 11 Commission Report* the four cities, or rather infrastructures at highest risk for an attack of bioterrorism include, Washington D.C., New York City, Los Angeles County, and Chicago. Out of these four cities the Department of Homeland Security places Washington, D.C. at the highest risk. The *Commission Report* also states that federal funding for emergency response in New York (City) and Washington, D.C. at the top of the current list (for funding). This thesis will focus on a response located within Washington, D.C.—the highest risk location for a bioterrorist attack. The proposed responses will take into account existing resources and capabilities within the D.C.’s urban context.

The reality of the threat of bioterrorism is something that Americans are aware of. According to research conducted by the Pro Research Center for the People and the

Press “the American people are beginning to get the message; nearly two thirds of us anticipate a serious terrorist attack on the United States using chemical or biological weapons within the next fifty years” (Osterholm, 8). Despite the increase in public awareness, in part because of financial limitations, emergency response and healthcare facilities remain unprepared for this type of threat. Significant gaps still lie between emergency responders and healthcare facilities due to the lack of coordination and preparation between these individual entities. The challenge of providing continuity between responders and healthcare facilities is still present and will result in an insufficient response unless all potential responders become integrated in their efforts.

Unpredictable Availability: September 11 established an awareness of the vulnerabilities of our national healthcare and security networks. In its analysis of potential terrorist threats, the Department of Homeland Security identified a range of potential acts of devastation and defined the reality of bioterrorism as the most significant health and security threat facing the US today. Significantly, “the conversion of commercial aircraft into weapons of mass destruction transformed the issue of catastrophic terrorism in the United States from theoretical to the gravely practical” (Hanfling, 140). Types

of weapons (in particular biological and chemical agents) predicted to be used during a bioterrorist attack are readily available and obtainable by potential terrorists. Predicted weapons “are a viable alternative to conventional weapons for terrorists groups and disgruntled individuals” therefore “this availability, coupled with terrorists’ willingness to use these deadly agents, has created a credible and serious threat to the nation’s security” (Waeckerle, 252). The increase and growing knowledge of the availability of weapons of this nature by terrorist organizations has produced a more viable threat awareness in the U.S. Despite the low probability of a bioterrorist attack placed upon the US, “the perceived threat of chemical or biological weapons (directed against the US civilian population) has increased substantially” (Macintyre, 242). Post-September 11:

‘Chemical and biological weapons have not been the focus of domestic planning, unlike our long standing preparedness for a nuclear attack. Today however, these weapons of mass destruction (WMD) are readily available to many countries...’ Additionally, ‘WMDs are a viable alternative to conventional weapons for terrorists groups and disgruntled individuals.’ (Waeckerle, 241)

The availability of weapons of mass destruction has the potential to produce unpredictable consequences, and is a growing reality to the health and security of the United States.

Unpredictable Flow: The contingent threat of a bioterrorist event remains the greatest challenge to healthcare facilities and emergency responders. The need for emergency response including health services provided within facilities and by first responders is difficult to predict making it hard to plan for an effective response over the inherently extended timelines of these events - especially the release of biological agents. Variables related to an act of bioterrorism are highly unforeseeable especially given the inability to predict the location of an event, the spread of impact and the number of victims that will be generated.

Healthcare facility planning and preparedness is considerably hindered by the nature of events predicted to occur. The fact that “the single greatest challenge to improving healthcare system readiness and capacity to handle large scale disaster events has been

the irrefutable fact that such incidents are low probability occurrences” (Hanfling, 130). An act of bioterrorism is a low probability, high consequence event. Low probability occurrences present a great challenge to healthcare facility planning and preparedness efforts and this is compounded by the potentially high consequences for lack of preparedness. Establishing the capability of an existing healthcare network to be all risks ready for a low probability event is nearly impossible due lack of funding and necessary resources.

Strategically planning for a bioterrorism attack involves many challenges of the existing healthcare infrastructure, in part because of the inability to provide surge capacity. Surge capacity is ‘the ability to manage a sudden, unexpected increase in patient volume that would otherwise severely challenge or exceed the current capacity of the health care system” (Hick, 2). During a bioterrorist attack, the number of victims generated is unpredictable and the number of locations in which they will seek care is highly unknown. Emergency responders will need to have the ability to react to a wide range of scenarios at potentially more than one epicenter. Efforts to strategically plan a response make “it is increasingly clear that disasters may ‘occur locally’ but the

response generated is ‘regional’ in nature” (Hanfling, 129). Any response model must therefore be distributed throughout a geographically broad threat context rather than be concentrated and centralized to single, isolated urban centers.

Architectural Response: Despite the fact that a bioterrorist attack has many variables and may potentially impact large geographic regions surrounding a targeted city or site, physical and organizational models of response to date are focused in a manner that establishes care in isolated and highly specialized, centralized locations, where all patients are expected to present themselves and receive care.

A specific example of this is ER One (Figure 3) at the Washington Hospital Center in Washington, D.C. Washington Hospital Center is located within a short distance from the US Capital and is currently the major trauma center within DC. ER One is described as an ‘all-risks ready emergency department,’ capable of responding to many variables of bioterrorism. The intent of what will be a highly safeguarded superstructure is that during an event within the setting of Washington, D.C. care will be delivered to all patients within this setting no matter where an incident occurs—a highly centralized

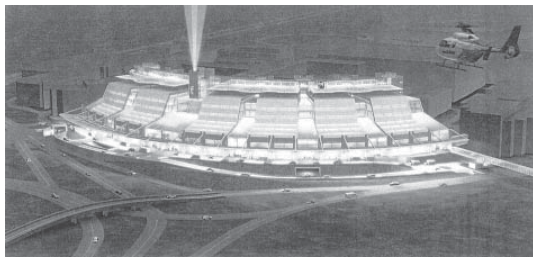


Figure 3, Proposed ER One Response

response to a very unpredictable, potentially decentralized event. The inefficiencies of a single healthcare facility responding to a major trauma event was illustrated in D.C. during Sept. 11 “of the 42 patients transported by ambulance from the scene of the Pentagon attack, not a single patient was delivered to the Level 1 trauma center (Washington Hospital Center) located 10 miles directly west of the disaster scene. All ambulance transfers went to the two closest community hospitals, neither of which has designated trauma care capabilities” (Hanfling, 136). Although the concepts and intentions of the ER One project meet the treatment needs of the variables presented during a bioterrorist event, it may in fact not meet actual response needs across the larger Washington DC metropolitan area since this type of setting is highly specialized and generally expensive to implement in sufficient numbers within a context.

In addition to multiple centralized treatment centers, emergency response capabilities must be dispersed throughout the larger urban threat context. There are two basic iconographic typologies of dispersed emergency response: limited resource, and unlimited resource.

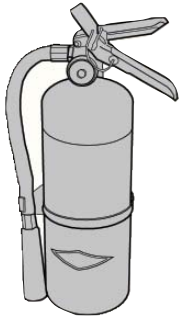


Figure 4, Fire Extinguisher

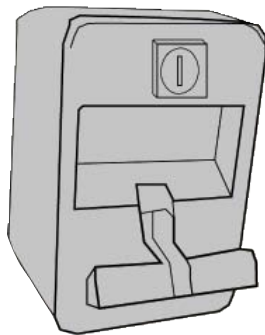


Figure 5, Fire Alarm

Limited Resource: Two examples of a limited resource emergency response would be fire extinguishers (Figure 4) or fire alarms (Figure 5). These small devices are repeatedly dispersed throughout a particular context. In the case of the fire alarm, once it is activated, a commanding network control center is notified and emergency responders with necessary resources are dispatched to the epicenter. Similar to these typologies of response, proposed architectural interventions such as self triage and public health information would be distributed throughout a context. During an event they would be used by individuals at the event location and controlled by the network control center. The proposed network control center would have the ability to notify and dispatch emergency responders once elements are activated.

Dispersed Resource: The second approach, in which response capabilities such as fire sprinklers in buildings (Figure 6), or oxygen masks in commercial aircraft (Figure 7) are widely available throughout the entire area. These systems are also typically connected to a communication and or activation network. Unlike a limited resource model, dispersed resource models typically do not rely on human activation, rather their response is often based on sensors monitoring an environmental condition. Once



Figure 6, Fire Sprinkler

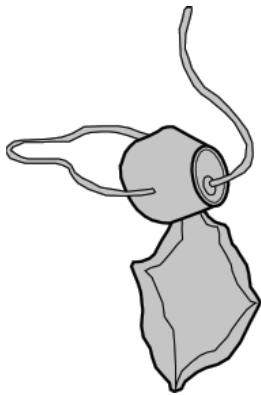


Figure 7, Oxygen Mask

sensors are activated a small scale response is deployed at a dispersed level throughout a particular context providing multiple responses to a number of people. This type of self-activated decentralized emergency response has the ability to respond to a multiple locations instantaneously unlike centralized emergency responses that require the delayed deployment of emergency responders traveling to a centralized location.

An example of this typology is the use of oxygen mask on commercial aircraft. During an emergency event in which a plane may be losing pressure, a monitoring and control system identifies that an emergency is occurring and oxygen masks are then automatically deployed. This form of response allows a high number of potential victims to be served where they are seated and immediately. In this case a dispersed response, distributed throughout a context is more effective on a per person basis for a range of event scenarios than a single centralized response capability.



Figure 8, Non Critical Patients

Anticipated Patient Flow

The most significant issue yet to be addressed is the capacity of a response to take into account the walking well—potentially the greatest number of patients generated during an act of bioterrorism.

Victim Typologies: According to the ‘Severity Predictor for Mass Trauma Events’ (CDC) there are two major types of victims that will be generated during a bioterrorist event – critical and non-critical. Critical victims, those that are either dead or terminal, those in immediate need of care and those that are admitted on a delayed basis are predicted to account for one-third of the casualties. Non-critical victims (Figure 8), those that need less acute or minimal care are predicted to account for two-thirds casualties generated during an event. The Centers for Disease Control also predicts that patterns of casualties may double if the event entails the use of manufactured weapons (such as fire arms), an explosion in a confined space, or the collapse of a building. The most common misconception of existing resources and their ability to respond is that existing healthcare facilities will be prepared to handle large numbers of acutely ill or injured patients” (Hanfling, 129). Many hospitals can already handle

critical patients predicted during a bioterrorist event yet they are not equipped with the necessary spatial and material capabilities needed to provide care to all potential (critical and non-critical victims). Minimal additional architectural interventions are needed to meet the needs of critical patients within a hospital. An architectural response located within healthcare facilities is not only expensive, but it is impractical to assume that architecturally the needs of all victims can be met within a healthcare facility. It is potentially more effective and less costly to meet the needs of non-critical patients away from the healthcare facility. To allow healthcare facilities to focus on providing care to critical victims, the needs of non-critical and the walking well must be addressed away from healthcare facilities. The greatest need for an architectural response and capital investment is on addressing the non-critical needs of the largest number of potential victims--the walking well.

Walking Well: In addition to critical and non-critical victims produced by an event the greatest number of victims who will present during an attack are the walking well. The walking well can be defined as people who will present themselves for medical care both with and without symptoms consistent with exposure. During an event,



Figure 9, Tokyo Subway Attack



Figure 10, Panic and Fear

people who suspect they are infected will greatly outnumber those who are in actuality symptomatic and potentially critically ill. During the 1995 Tokyo subway (Figure 9) attack by the Aum Shinrikyo terrorists, the walking well turned out to be nearly 4,500 of the approximate 5,000 reported casualties. It is believed that “for every casualty injured or infected, hundreds more may seek evaluation” (Hick, 5). It is estimated that the number of walking well may exceed the number of exposed victims by 5 to 15 times. The potentially large number of unverified victims who may show up at hospital emergency departments have a great potential to inundate healthcare facilities and emergency response during a bioterrorist attack, and therefore provide the biggest challenge to any response effort. In order to allow the healthcare system and emergency responders to effectively respond to the needs of critical and non-critical victims, a response must be designed to identify and meet the needs of the walking well before they arrive at area hospitals.

Panic and Fear: Panic and fear (Figure 10) will be most evident during an event and “the widespread terror caused by the use of (bioterrorism) weapons could complicate response needs” (Macintyre, 243). The general public lacks knowledge of the agents

potentially to be used during an attack. Currently, there is little understanding of the details of how biological and chemical agents are spread, what the symptoms are, and what (typical) outcomes entail. It is predicted that the walking well will assume the worst case scenarios due to their lack of knowledge.

During an attack of bioterrorism, panic can be reduced by “reinforcing the public’s sense of control” through more obtainable access to self diagnosis services and opportunities to remotely receive event related information (Glass, 3). Providing the public with information pertinent to what is taking place around them during an unfamiliar event can alleviate a great deal of fear and panic. A response that addresses the needs of the walking well can potentially reduce the probability of those not requiring treatment from inundating healthcare facilities—so health care responders can focus their resources on treating those actually infected. Similarly a dispersed diagnostic response can allow people to better identify their individual medical needs and take appropriate actions rather than rely on emergency responders or medical staff who during an event will need to be focused on administering treatment to critical patients.



Figure 11, Mobile Chemical Agent Detector



Figure 12, Decontamination

Predicted Incidents

A bioterrorism event can include the use of chemical, biological or radiological agents as weapons. Biological and chemical agents are considered the most obtainable weapons of mass destruction and will be the focus of this thesis. The potential impact of any type of incident is immense due to the fact that “there is little or no ability to anticipate a chemical or biological attack, little or no ability to detect one if it occurs, and little ability to manage the consequences” (American Health Consultants, 5). It is nearly impossible to contain an agent from spreading throughout an environment, especially those that occur outside of buildings; therefore these agents are capable of spreading throughout a context very easily. With the exception of a few chemical agents, most weapons (chemical and biological) used during a bioterrorist event are generally invisible and odorless making detection without the assistance of special equipment (Figure 11) difficult. Chemical and biological weapons impact their victims differently including the length of time before symptoms present themselves and the way in which an agent is transferred from victim to victim. The delivery of care for each type of weapon has several variables such as the need for immunization or immediate decontamination (Figure 12) as well as the type of symptoms that occur after the contact with a weapon

| | Onset (in hours) | Transfer | Immunize | Decon. | Symptoms |
|--------------------|---------------------|---|----------|--------|---|
| Sarin | Varies | Trapped in clothing for up to 30 minutes, possible skin contact | Y | Y | Runny nose, weakness, blurred vision, etc. |
| Ricin | 18-24 | Not spread by casual contact | N | Y | Sudden fever, cough, respiratory |
| Mustard Gas | 2-48 | Lasts 1-2 days in normal environment. Casual contact | N | | Skin, eye, respiratory and digestive irritation |
| Chlorine | 0 | Contact with clothing | N | Y | Burning sensation in eyes, nose, nausea |

Figure 13, Variables related to chemical agents

of bioterrorism.

Chemical Incidents: (Figure 13) Due to their ability to produce an almost instant reaction, chemical agents are weapons of immediacy. Generally, these types of bioterrorist weapons are odorless and colorless therefore having the greatest ability to incapacitate those that come in contact. Identifying the total physical area that may or may not be contaminated is problematic as most agents are not capable of being detected without the assistance of technology. In high risk urban environments technological devices are assisting law enforcement and public health officials in the (constant) monitoring and real time evaluation of air quality. Devices are located discretely throughout populated, high threat areas, such as the National Mall (Figure 14), or Metro (transportation) system (Figure 15) in Washington, D.C. These types of systems alert officials if a chemical agent has been released into the environment at a higher than anticipated level.

Chemical agents have the greatest ability to immediately impact the human body; however it is possible for some types of chemical agents to take several hours to days (at most) to become recognizable. Victims that have been exposed to a chemical agent need to be immediately decontaminated before the chemical agent further infects their



Figure 14, National Mall



Figure 15, Transportation System

body. Due to the likelihood of traumatic stress that chemical weapons pose to the body, a response should be activated and primary emergency care such as decontamination should be delivered at the epicenter. It is important to remove the agent from direct contact with the victim to limit its impact as well as minimize the exposure of healthcare and emergency responders treating the victims. Delivering care at an epicenter allows less severe victims to also be decontaminated and initially treated before they disperse throughout a context.

The primary programmatic response to a chemical attack is decontamination (Figure 16) the process of physically removing (by washing) an agent from an exposed victim. The process of decontamination includes the removal and disposal of clothing, a series of showers that use a mixture of water and disinfecting products, and re-gowning. It is significant to provide care at the epicenter immediately due to the fact that decontamination resources available at nearby healthcare facilities would probably be insignificant in size to meet the demands of patients (including non-critical, and the walking well) predicted to present during a large scale event. Healthcare facilities today are typically equipped with small decontamination showers located at the



Figure 16, Typical Decontamination Equipment

entrance to an emergency department, a centralized response location. With the system of response that exists today, after “the release of a chemical weapon in a populated area, casualties may present en masse with little or no advance notification” (Macintyre, 242) potentially inundating existing emergency response capabilities. By deploying decontamination resources and capabilities at the epicenter once a release of a chemical event has been identified, healthcare facilities can more adequately respond to victims who may need more sophisticated follow up care.

The release of a chemical agent can also impact the population located outside of the immediate epicenter; these probable victims will typically not have an immediate awareness of their exposure due to their location relative to the epicenter. Therefore, the potential is high for infected victims to disperse throughout a context. Despite difficulty of containing all infected patients at the event site, the further dispersion of an agent is somewhat inhibited by the low probability of spreading a chemical agent through casual person-to-person contact. Residue from the release of an agent typically is present within a victims clothing but can not be spread to an uninfected person through casual physical contact. Allocating treatment at the epicenter can minimize the number

| | Onset | Transfer | Immunize | Decon. | Symptoms |
|-------------------|--------------------------------------|--|----------|--------|---|
| Anthrax | 1-6 days | Not passed person to person | Y | Y | Cutaneous: sores Gastro: Nausea Inhaled: cold or flu like symptoms |
| Salmonella | 11-72 hours | Consume contaminated foods | N | N | Diarhea, nausea, abdominal cramps |
| Small Pox | 2-3 days OR 16-17 days | Prolonged face to face contact with infected person in a confined area | Y | N | Fever, headache, body aches, then a rash that develops into infected blisters |
| Plague | 2-3 days | Prolonged face to face contact | Y | N | Fever, nausea, weakness, vomiting |

Figure 17, Variables related to biological agents

of patients dispersing beyond exposed areas during a chemical attack. The ability for any response to activate immediately once a chemical agent has been dispersed and recognized is significant because the symptoms will begin their onset within victims immediately upon exposure. Treatment in the form of decontamination should occur immediately so that symptoms do not progress unnecessarily.

Biological Agents: (Figure 17) Considering the ability biological agents to incubate within their victims for several days before their onset and presence is known, biological agents are weapons with a delayed but potentially larger and more prolonged impact. Biological agents appeal to terrorists because of the inability to quickly detect their presence, therefore allowing no trace of the initial release and source. Not only are biological agents obtainable, they are attractive due to that fact that “in many instances, these weapons are relatively easy to produce, inexpensive and can be deployed covertly” (Macintyre, 243).

The potential for a bioterrorist attack to have a greater impact manifests itself in the nature of our society. Our culture is very transient which increases the potential impact

of a biological attack. Once an agent is released, infected people could disperse without knowing that they were exposed, increasing the potential impact of the event dramatically. People leave the epicenter infected, and traverse throughout densely populated settings such as stores, airports, transit systems, schools, etc unknowingly exposing those around them. An appealing aspect of biological agents is the probable dispersion of disease through the mobility of its victims “the fact that the victims are on the move, dispersing around the country or even around the world” (Osterholm, 71). Despite the possibility for an agent to spread throughout a geographical area within its victims, most biological agents can not be transferred through casual contact. In order for an agent to spread, infected bodily fluids must infect new victims; this often requires a long face to face contact in a confined/crowded setting, such as trains, subways, airplane, buses, cues at platforms and ticketing counters, with little airflow, between an infected victim and a potential secondary victim.

The symptomatic conditions of biological agents and the similarities they share with the ‘common flu’ increase the appeal of releasing biological agents—medical staff typically do not diagnose exposure to a biological agent until several days after numerous patients

with similar symptoms begin to present themselves. Thus, “the only certain way to detect the agent is through the eventual presentation of symptoms and then diagnostic testing which will be retrospective for most casualties “(American Health Consultants, 5). Once an agent has been confirmed to the public, fear and panic will be exhibited by the general population including those not exposed. It is unlike a chemical attack where the epicenter can be identified and patients can more easily be tracked. A large number of widely dispersed biological event victims will be generated because of the inability to determine the definitive area of release. A response to bioterrorism must therefore be dispersed throughout a larger context similar to the manner in which the agent disperses in order to reach the highest number of potential victims.

A significant programmatic response to bioterrorism includes isolation of exposed critical victims; however this is not the primary architectural and interventional needs due to the fact that the majority of people who may seek treatment will in fact be the walking well. Isolation can be administered at hospitals for critical victims and larger numbers of non-critical victims can be held in isolation for observation purposes at alternative care locations such as designated hotels, and clinics throughout a context.

In addition to the obvious need for isolation, the primary programmatic response for a biological incident is diagnosis and triage. During triage (the initial stage of delivery) it would be determined whether or not a patient has been exposed based on simple vital statistic monitoring. Care varies depending on the degree of onset once a patient has been diagnosed. Most victims are immunized and discharged unless their symptoms have progressed to a critical stage in which case they would be admitted to a healthcare facility where they would be placed in isolation. It is reasonable to assume that primary care for non-symptomatic patients can be administered at alternative care locations and dispersed response settings, allowing healthcare facilities to focus on the delivery of care to critical victims whose exposure has progressed to the point of recognizable symptoms needing treatment and isolation.



Figure 18, Transit Network



Figure 19, National Mall, Washington, D.C.

Predicted Scenarios

Many types of probable scenarios could be executed with bioterrorism producing a great impact on the population. When selecting a target, (bio) terrorists can be reasonably assumed to target a multitude of location types. “In a terrorist’s eyes, the higher the profile of the attack site, the more attraction” (Osterholm, 71). Potential high profile attacks sites include transportation networks (Figure 18), spaces (both interior and exterior) in which large gatherings take place (Figure 19), as well as high profile (federal) buildings (Figure 20). Despite these criteria, a terrorist may attack any number of related or unrelated locations in addition to those listed above. According to the United States Department of Homeland Security “attacks by international and domestic terrorists have demonstrated that no location is immune (to attack)” (U.S. Department of Homeland Security, 13) therefore safeguarding a specific type of locations is irrelevant when establishing response strategies for a bioterrorist attack—a response should therefore be dispersed and able to adapt to the demands of various types of scenarios.



Figure 20, High profile buildings

The density of an urban context can be considered an ideal location for bioterrorism because of the many probable locations for an event to be initiated. People in cities are mobile—many commute to surrounding suburbs or are visiting from other places. In regards to the way that we build cities, “vast spread out, and prosperous, these highways, clusters of office towers, mega malls and suburbs, each feeding on the other” (Osterholm, 73) make cities ideal targets for promoting the most devastating movement of a disease. Any attack of bioterrorism would be exemplified by the high number of people that could potentially be infected if an attack were to take place within an urban context.



Figure 21, Mock Chemical Incident



Figure 22, Mock Chemical Incident

Probable Event Typologies

Any architectural and systemic response to bioterrorism must have some scale-ability of response during the timeline of a bioterrorist attack allowing response efforts to fluctuate with the demands of patient flow (or lack there of). Current technology allows executives and officials the opportunity to illustrate and play out potential and probable scenarios and event timelines, either practically or virtually, and evaluate their performance before, during and after their conclusion. By performing these exercises (Figure 21, Figure 22) officials can begin to understand efforts necessary to establish a strategic plan. The federal government has tested the capability of existing resources during several national exercises. This thesis will adapt the framework and assumptions for these exercises to Washington, D.C. and will set forth the criteria for testing proposed systemic as well as architectural responses to bioterrorism through the utilization of existing infrastructure within an urban context.

Prior to the establishment of federal mock-events, no exercise had tested how existing systems would respond to an event of bioterrorism. Federal mock events take into account efforts made by all possible players including healthcare facilities and emergency



Figure 23, TOPOFF Exercise

responders. During the initial events it was evident that no component as a single entity would be able to handle full responsibility, therefore coordination was necessary so that each type of responder could focus on responding efficiently. Federal exercises known as TOPOFF ('Top Officials') exercises (Figure 23), set forth by the federal government in part because the "people who would truly be making the decisions in a real event had never had the chance to become familiar with procedures and protocols" (McBaugh,1). These types of exercises allow key players the opportunity to see how things will play out in a situation less stressful than the chaos predicted to occur during an actual attack. TOPOFF exercises are considered to be "the most comprehensive and 'real' test of local, state and national response capabilities ever conducted in our nation's history" (McBaugh, 1) and past exercises exhibited both weaknesses and strengths of existing responders. Post event evaluations proved that performing these types of exercises was significant in establishing and designing comprehensive, coordinated responses between agencies designated to respond. Emergency responders were made aware of partnerships and the roles that each one would play during the timeline of the entire exercise. Despite the efforts being made by responders, many gaps still lie in the overall response strategy because responders are developing individual plans that are therefore redundant and not a comprehensive of the abilities of all typologies of responders.

Timelines taken from Questerra, Center for Strategic and International Studies and Biohazard News for two events will be used as a general framework for establishing an evaluation of the proposed architectural and systemic response in this thesis. Any response must not only take into account the ability of each responder as a single entity, but more importantly a response should take into account providing a solution that allows both healthcare facilities and emergency responders to focus on providing a effective response. The major variables that can potentially inhibit responders from reacting effectively to an event are the number and role of people who will need to be seen in any one location. A systemic and architectural response to bioterrorism should take into account the incorporation of various types of decentralized, activated and deployable responders within an urban context external including existing healthcare and emergency response services.

The two most predicted typologies of a bioterrorist attacks will be studied in this thesis--a chemical attack, as well as the release of a biological agent. The events will vary in size so that the ability of the proposed response will be examined on two different scales in an attempt to illustrate the capability of the proposed systemic and

architectural response. This thesis will also assume that the role of existing emergency responders and existing networks of response will be present during a response. The chemical event will assume a smaller number of patients in a concentrated area, and the biological event will assume a greater number of exposed victims throughout a broader context. Due to the response time difference and identification of chemical (immediate response) and biological (delayed response) attacks, the timeline for each scenario will vary. The chemical event will only last for three days, where the biological attack will continue for twelve days. These two events are very dissimilar and were chosen to consider the ability of the proposed systemic and architectural response under two variable conditions. Despite the dissimilarities between the two events chosen to test the proposed response (different agents, different length of response time, different number of patients and walking well, and different type of response) both were chosen because they are predicted to be the most likely type of bioterrorist event that may occur. (Figure 24)



| | <i>Event 1: Chemical Agent Release</i> | <i>Event 2: Biological Agent Release</i> |
|--|---|---|
| <i>Agent Released</i> | Mustard Gas | Anthrax |
| <i>Release Location</i> | National Mall, Outdoor Setting High Profile Location | RFK Stadium, Outdoor Setting Densely Population |
| <i>Recognition</i> | Immediate | Delayed—several days |
| <i>Response Duration</i> | Three days | Twelve days after recognition |
| <i>Patient Population</i> | 150 patients exposed, 50 of which are critical | 50,000 exposed, 13,000 of which are infected |
| <i>Delivery of Care</i> | Decontamination | Triage and Immunization |
| <i>Response Location</i> | Epicenter | Alternative Care Locations throughout urban context |
| <i>Activated Architectural Response</i> | Public Health, Self Diagnosis | Public Health, Self Diagnosis, Wayfinding |

Figure 24, Comparison of Scenarios

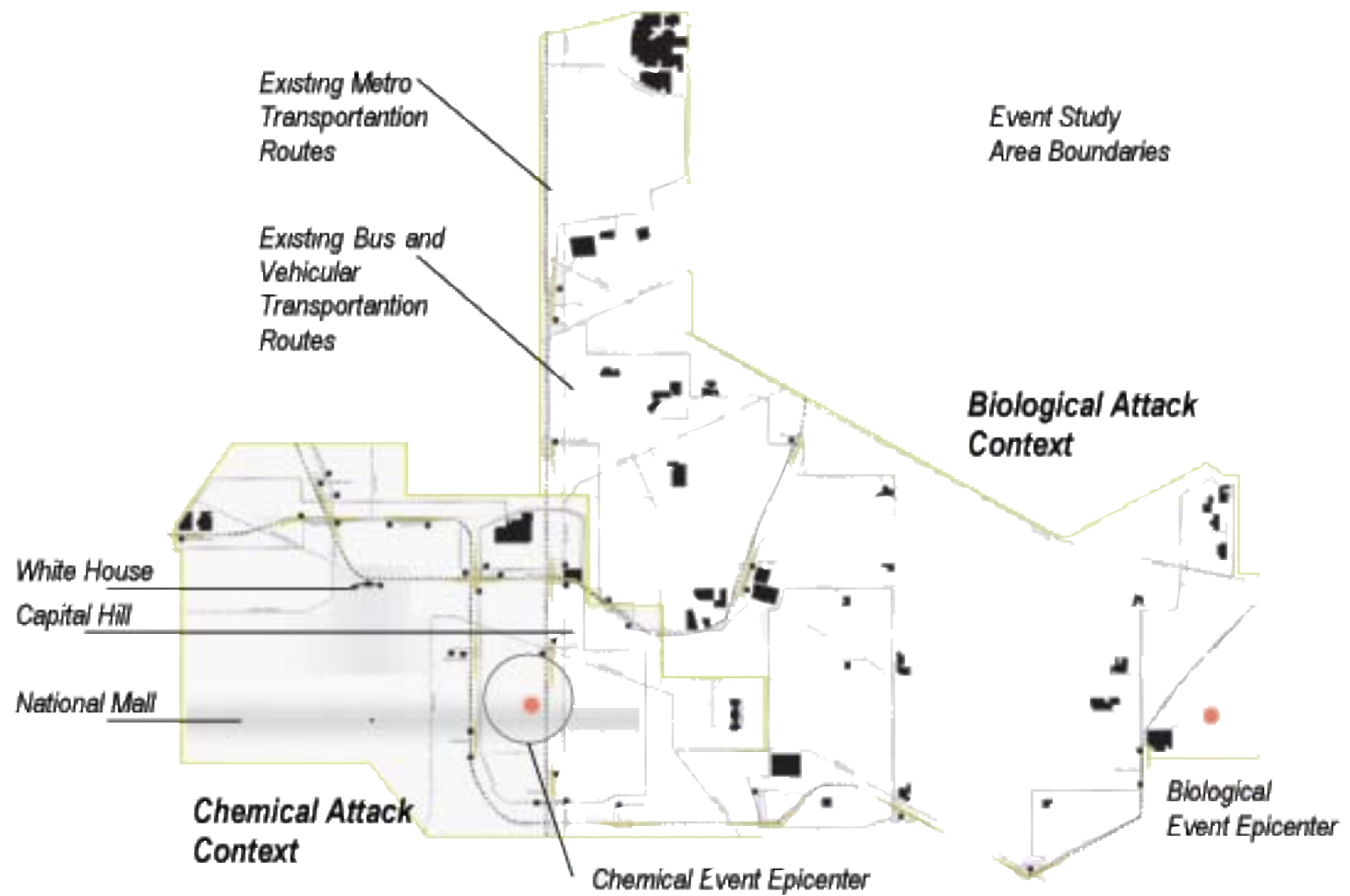


Figure 25, Enlarged Diagram of Scenario Contexts



Figure 26, Capitol Hill

Events Scenario 1, A Chemical Attack on the National Mall: The first event study, a chemical release (mustard gas) on the National Mall, is an outdoor setting. The National Mall is located in an area of Washington DC where there are many predicted potential targets of attack including prominent Federal buildings within close proximity—including Capitol Hill (Figure 26), and the White House. The target site is a heavily populated area, as the National Mall on a daily basis attracts many tourists. The urban district surrounding the epicenter of this event contains many museums, and outdoor monuments. (Figure 25)

This event provides an opportunity to consider the ability of the proposed architectural and systemic response to address the needs of a small event, with only 150 people at the event epicenter actually exposed to the agent—fifty of which are diagnoses in critical condition. The duration of the event will last for three days, and will require an immediate response. The response context in this case will be located at the epicenter and will utilize existing response resources including the National Metropolitan Response Team (NMRT). The primary delivery of care that will be administered at the epicenter would be decontamination. Critical patients in need of further care would be

transported to a local healthcare facility by existing emergency responders. Despite the delivery of care at the epicenter, people at the periphery of the event will likely disperse throughout the urban context and be informed of the event through the activation of architectural and technological interventions within the immediate context including public health information, and self-diagnosis. Diagnostic capabilities can serve these people who will likely think they have been infected in an effort to minimize mass hysteria in the general population from inundating existing healthcare facilities as well at the epicenter of the event.

This event scenario will be used to study how an architectural and systemic response could activate immediately and serve a potentially high number of victims (critical, non-critical and the walking well) within a short duration of time. It also illustrates how existing resources (NMRT) would be integrated into the timeline of response.

Event Scenario 2, Anthrax released during an event at RFK Stadium: The second event study is located within a large outdoor context that includes not only the stadium, but the immediate urban context that surrounds it as well as the larger metro region, specifically Maryland and Virginia. (Figure 25)

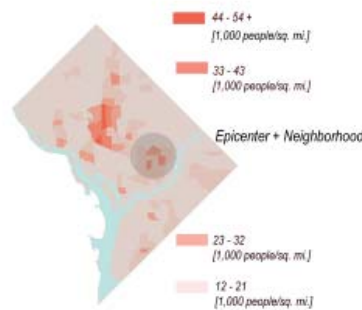


Figure 27, Population Density Surrounding Biological Event Epicenter

This event tests the ability of an architectural and systemic response to react to a large patient population. During the time in which the agent is released, a population of 50,000 attendees is assumed to be at RFK, 10,000 of which will be diagnosed as critical, in addition to 3,000 (critical) residents from the surrounding residential areas. (Figure 27) The agent and the release are not identified immediately, and go unnoticed for several days until patients begin to present themselves at local healthcare facilities with symptoms of the flu. The time between the release of a biological agent and recognition can be a matter of days, unlike the immediate recognition of a chemical agent. The delay between release and recognition allows victims to disperse throughout the immediate urban context (Washington DC) and the surrounding metropolitan area (Maryland and Virginia); therefore they cannot be as easily and quickly contained and identified as they can be during a chemical release. The delay in recognition will inherently produce thousands of walking well; as a result hundreds of alternative care locations (varying in size) will potentially need to be activated to prevent this patient population from presenting themselves at healthcare facilities. The primary delivery of care at alternative care locations and kiosks within the metro stations will include triage. Alternative care locations will potentially provide antibiotics and immunization

to diagnosed patients. In order to supplement care at established health facilities and alternative care locations the primary architectural and systemic response interventions proposed in this thesis will include sites for obtaining and disseminating public health information, and opportunities for self diagnosis, including thermal scans and self-diagnosis terminals at a dispersed level throughout the DC urban context. These sites will provide an opportunity for potential victims and the walking well who have dispersed from the initial epicenter to determine whether or not they have been exposed.

This event is architecturally and systemically significant because of the prolonged timeline, and the high number of victims (primarily the walking well) that will utilize the response. An architectural response to a biological attack will need to be able to quickly adapt existing non-traditional healthcare settings and be able to sustain a response over a prolonged period of time. Programmatic responses will need to adapt to their inconsistent, unpredictable physical environments repeatedly throughout an urban context. For example triage within a school cafeteria varies in configuration to that provided within a large arena. A response to a biological event will be activated on a widely dispersed level throughout the entire urban context, and will serve a potentially high number of walking well over an extended period of time.

Existing Response Context

Healthcare facilities are inadequately prepared to respond to bioterrorism due to a lack of physical space and staffing as well as the inability to stockpile supplies. During an event of bioterrorism, healthcare facilities are currently assumed to be able to “care for overwhelming numbers of patients; manage shortages of personnel, medicines, and equipment; and provide the security needed for crowd control, for the provision of safety for healthcare workers and patients, and even perhaps for the enforcement of mandatory isolation of contagious patients” (Inglesby, 443). The low probability, high consequence nature of bioterrorism makes it impractical and financially overwhelming for all potential response hospitals to become all risks ready. The reality is that healthcare facilities are “an essential component of the emergency response system and at the present are poorly prepared for such incidents” (Macintyre, 1). Inherently hospitals provide concentrated urgent, acute and ambulatory care services and are somewhat dispersed throughout an urban context but not in a strategic way. Relying on healthcare facilities to provide care for all real and imagined victims is unrealistic planning for such an unpredictable event. Any response to bioterrorism must also take into account decentralized locations and existing resources identified, organized and



Figure 28, Patients

distributed broadly throughout a threat context so that the greatest number of victims can be treated.

Mass Casualty: Typical spatial and clinical resources within hospitals lack the ability to meet the projected demands associated with a potential mass casualty event such as a bioterrorist attack. There is a significant gap between existing resource allocation and the projected demands associated with all predicted mass casualty typologies—especially the perceived needs of the walking well (Figure 28). Generally, localities define a ‘mass casualty event’ as one with more than a dozen casualties; far less than an intentional release could cause (Siegrist, 3). Most hospitals on a daily basis face the strategic challenges of being ‘at capacity’ with a number of patients entering through the emergency department that is far fewer than those expected to arrive due to a bioterrorist attack. Healthcare facilities “lack the capacity to cope with an unexpected surge in patients” (Glass, 4). During an episodic event, such as a bioterrorist attack, hospitals are at best typically prepared for limited “mass” casualties. Throughout the TOPOFF exercise healthcare facility capability was tested:

‘Even at the outset of the epidemic, hospitals were quickly seeing

far more patients than they could manage. In the beginning, two to three times normal volumes and later up to ten times normal volumes were converging on health care facilities” (Inglesby, 4).

The impending threat of a bioterrorist attack has redefined mass casualty in theory and the way in which actual emergency care is delivered in an effort to incorporate the need for high surge capacity. Most hospitals, especially those within an urban context lack the physical ability to grow and expand to meet the demands of the resulting surge of patients during an event of bioterrorism. Response strategies need to expand beyond the capabilities of existing healthcare facilities in order to meet the demands of all potential victims of a bioterrorist attack. Response strategies need to include alternative care locations such as schools, hotels, and arenas dispersed throughout an urban context that can be quickly converted as appropriate to accommodate the predicted demands of mass casualties within an urban context to serve as nontraditional healthcare settings during an event. Traditional models of healthcare should take into account the unpredictability of scope and location of an attack and should therefore be capable of extending beyond the walls of a hospital in order to provide a dispersed response within an urban context that meet the demands of all potential victim typologies during a bioterrorist attack.



Figure 29, Decontamination Shower

Emergency Response Options: Emergency Departments (EDs) do not have the capability to provide emergency response options to meet the demands of all variables related to a bioterrorist attack. Currently “the majority of Emergency Departments (EDs) are not prepared for this type of event (incident) should it happen today” (American Health Consultants, 95). It is impossible to think that all emergency departments will financially be able to prepare and safeguard for all variables of a bioterrorist attack, in part because of the low probability occurrence of an event in any given location.

Hospital emergency department facilities are specifically inadequate for providing response options during a chemical attack as, “many healthcare facilities are poorly prepared for the decontamination requirements of even small scale HAZMAT incidents” (Macintyre, 243). Typically EDs are equipped with a single occupancy decontamination shower (Figure 29) located near the ambulatory entrance; this model is geared toward industrial accidents and only capable of handling one person at a time during minor emergencies such a single patient exposure to a hazardous material. Furthermore decontamination while a necessary component of a chemical attack, is not programmatically needed during the administering of care for patients exposed to a biological agent.



Figure 30, Typical Mobile Response

During a biological release, triage would be the most common programmatic function delivered to the greatest number of patients. Typically EDs are equipped with few triage bays, generally a number far less than what would be needed to respond to the predicted number of victims during an event. The vast majority of potential victims needing screening and initial diagnosis should not have to rely on seeking care from a healthcare facility that would quickly be at capacity and therefore unable to deliver care within an adequate amount of time.

In some instances, healthcare facilities are preparing themselves for a bioterrorist attack by equipping their emergency department with a typically small scale mobile response unit, such as a trailer (Figure 30), or shipping container, that remains dormant during normal operations but can be activated or deployed as needed during a surge event. These units contain shelter components (such as a tent) and medical equipment needed to provide a response during a surge event. These types of response units are usually equipped with temporary shower structures to provide decontamination during a chemical event. Most of the equipment stored within these types of containers pertains only to chemical attack response efforts; during a biological attack however, the shelter



Figure 31, Shelter

component stored within these containers could be utilized to support alternative care locations. (Figure 31) Containers used to store equipment and supplies, whether trailers or shipping containers latently serve as equipment storage; the physical structure of the container wouldn't provide adequate area to assist in the delivery of care when the supplied within the container were activated.

During an event these units can either be used on site (within a medical campus) as an immediate extension of a response offered by an ED or transported to an offsite care location such as the epicenter. Mobile units would also have the ability to be an extension of care delivered at alternative care locations, such as clinics, schools, arenas or hotels—the type of response at these locations would depend on the type of event. Mobile models deployed throughout an urban context during a response could potentially alleviate pressure otherwise placed on hospitals by less acute victims and the walking well. A response to a chemical attack may require that a unit be deployed to an epicenter so that critical patients are treated before they are transported and are immediately decontaminated onsite. A biological attack, primarily because of the time delay between release and recognition of an agent, may require that a mobile unit be

activated onsite at a healthcare facility or alternative location (school, hotel, clinic, etc.) and serve as an extension of existing services such as triage. Factors such as scale and type of event and dispersion of victim population will determine whether or not mobile units should be deployed or remain at an established response location such as a hospital. Other types of response can be activated throughout a context with minimal human assistance in order to provide public health information, self diagnosis, and wayfinding to potential victims, and the walking well.

Regardless of its activated location, mobile units need resources—electric, water and communication lines to operate during an attack. Gaining access to these resources when a mobile unit is activated at an existing facility is obtainable; if a mobile unit is going to be activated remote from a conventional healthcare facility or alternative care site, the same basic resources must be available for the delivery of care to take place. Offsite locations where mobile units may be activated is hard to predict prior to an event, therefore this type of response “may present logistic challenges, such as availability of plumbing and water” (Hick, 6). Mobile units deployed to an off site location, such as the epicenter, would be primarily used during a chemical event to

provide decontamination to patients. Units deployed to administer decontamination can not function without access to a water source. It can be assumed that deployed units would utilize fire hydrants and have the capability to be hooked up to existing or portable sources of electric power as needed. The availability of resources during a response activated at an offsite location should be considered so that mobile models are reliable and efficient in establishing a response setting.

Current mobile units must be able to adapt to the location in which they are activated. For example, they can be activated in open plazas, parks and even on streets with the assumption that road closures will occur during an event. During an attack a mobile responses can function as an individual entity or as an extension of a care or alternative care locations established as part of the urban infrastructure. It is unpredictable where a response will need to occur therefore any component of response will need to be adaptive to all potential environments in which care could be delivered.

Existing Emergency Responders: During an act of bioterrorism current Federal emergency response plans currently incorporate the capability of various types of

emergency responders including fire, rescue, and law enforcement, emergency response medical staff, local ED's as well as HAZMAT teams previously mentioned in this thesis. Emergency responders have the potential capability of immediately arriving at the epicenter and to administer initial care.

Like hospitals, emergency responders can not function as single entities in isolation and be capable of providing care to all victims generated during either a chemical or a biological attack. They are currently integrated through an established network of communication so that each component has an immediate awareness of current emergency situations, and the involvement needed. For example, during an emergency response in which medical care is administered, victims may need to be transported to a healthcare facility. The emergency response network control center has the ability to communicate with hospitals to determine availability as well as make them aware when patients will arrive, and their medical status. Each emergency responder would have a role during both typologies of event similar to the type of response that they currently perform.



Figure 32, Hazmat Teams



Figure 33, Hazmat Teams

HAZMAT teams (Figure 32, Figure 33) also typically exist within a response network. This type of responder is activated during situations in which a hazardous material may need to be contained, or removed. Similarly, they have the ability to treat victims that have been exposed to hazardous materials. HAZMAT teams, by the conditions in which they were designed to respond to, are prepared and heavily equipped to handle variables related specifically to a chemical attack. HAZMAT teams also coordinate a cohesive and communicative response with all components of emergency response including healthcare facilities during a response situation.

HAMZAT teams are specially created to have the ability to provide decontamination during a chemical event. A response that focuses on providing decontamination is not adequate for a biological attack. Triage and immunization are the primary programmatic responses needed for a biological attack. According to a bioterrorist specialist, “the most important flaw is the fact that the HAZMAT model does not address the use of biological agents,” more specifically “traditional HAZMAT products, such as decontamination tents, trailers and isolation rooms, are expensive, require prolonged setup time or are inadequate for large numbers of patients” (Macintyre, 243).



Figure 34, NMRT onsite



Figure 35, NMRT Resources

During a response to a chemical attack it can be assumed that critical patients will be treated at the epicenter by responders such as HAZMAT teams; yet it can also be assumed that all remaining victims will not be treated and decontaminated by HAZMAT teams at the epicenter. HAZMAT teams are adequate resources to specifically treat critical patients—a much smaller patient population than the walking well who can be more appropriately addressed at dispersed locations throughout the event context.

Post September 11, provisions for emergency responders were reconsidered by federal agencies. This includes “efforts to increase federal, state and local response capabilities, develop response teams of medical professionals, increase availability of medical treatments, participate in and sponsor terrorism response exercises, plan to aid victims, and provide support during special events such as presidential inaugurations, major political party conventions” (Heinrich, 5). The National Metropolitan Response Team (NMRT), located in Arlington, Virginia, is an example of a federally funded response team (Figure 34, Figure 35). Established by the Department of Homeland Security, NMRT is comprised of volunteer on call first responders (fire, EMS, law enforcement)

and healthcare personnel. During an instance of terrorism (such as September 11) within the D.C. metropolitan area, NMRT responders are alerted. Once notified, all responders convene at NMRT (in Arlington) and dispatch to the epicenter or response location jointly where they set up an area to provide large scale decontamination and triage. In some instances NMRT is also deployed prior to high security events within Washington, D.C. as a means of preparation for potentially high risk scenarios of bioterrorism such as large gatherings on the National Mall, or political events similar to an inauguration. NMRT is equipped with the necessary supplies to provide decontamination, as well as medical resources and personnel to administer the immunization, and treatment to a patient population larger than most local responders would be capable of during a bioterrorist event including critical and non-critical patients.

NMRT was designed with the intention of providing response during worst case, bioterrorist scenarios such as an attack during a high profile event in Washington DC where large numbers of patients could potentially be generated. NMRT is an excellent mobilized model of response capable of providing large scale decontamination quickly during a chemical attack due to their ability to be self-sustaining without connecting

to existing electrical and water resources. Additional response proposals need not duplicate or overlap with the responsibilities of the NMRT to provide decontamination during a chemical event. The NMRT must be considered as a component and model of response during strategic planning for a bioterrorist event.

Inadequate Integration

While certain healthcare and emergency response models may adequately respond to the needs of bioterrorism in certain places under specific conditions, there is no fully developed systemic response capability designed to handle the predicted range of potential scenarios, locations and scales of events. One major flaw in a systemic response strategy is that healthcare facilities and emergency response options are not adequately integrated. For a sufficient response to occur during a bioterrorist attack, healthcare facilities and emergency responders need to be consistent and coordinated in their planning efforts and integrated in the manner in which they respond so that redundancy does not occur.

Based on the fact that the “healthcare system is often operating at or over capacity daily, we will never have the resources to be prepared for every disaster, but with appropriate partnerships, incident management systems and a tiered response framework, we can be prepared to respond to any challenge” (Hick, 9). Appropriate partnerships include emergency responders and healthcare facility medical staff working together at a localized level in order to establish a familiarity of responsibilities and a relationship

prior to an event. During the Topoff Exercise new working relationships between responders and larger national agencies were defined; ‘although hospitals and local and state health agencies often collaborate with the Centers for Disease Control and Prevention in controlling an epidemic, (we) were unaccustomed to working closely with the Federal Bureau of Investigation, the U.S. Attorney’ and other major Federal Agencies (Hoffman, 1). All types of responders must be coordinated; in particular the relationship between emergency responders who will administer decontamination at the epicenter during a chemical attack and healthcare facilities that will be receiving critical patients from the epicenter is necessary. In an effort to assist in mitigating the needs of the walking well throughout an urban context so that this particular patient typology won’t inundate and seek care from traditional healthcare facilities, public health information and crowd control must be provided through the coordination of law enforcement and public health departments.

During an event all responders should understand their role and responsibility allowing each individual entity to focus on their role in the delivery of care to victims.

An incident management system and a tiered to plan of action would establish a framework for response efforts by allocating the accountability of individual responding

agencies. As well as defining roles and responsibilities during an emergency, all responders identified in a tiered response should have an understanding not only of their individual responsibility, but also who they should be communicating with during a response effort and what roles and responsibilities other agencies are accountable for. During the Topoff exercise despite the fact that roles of authority were defined ‘much time was spent in consultation and debate (regarding roles and responsibilities) through scheduled (bridge) calls’ therefore decision making became ‘inefficient’ (Ingelsby, 2). It became very evident that during an event ‘a central location for face-to-face meetings should be large enough to accommodate representatives from all agencies involved’ (Ingelsby, 2). It is also necessary that emergency strategies are outlined prior to an event so that responders are able to focus on the responsibility of providing care rather than trying to understand strategic framework challenges during the chaos of an event.

There is a significant disjoint between healthcare facilities, and emergency response options. During the Topoff exercise Emergency Operation Centers (EOGs) were defined by federal, state and local agencies prior to the event in an effort to establish a central network control center ; during the response “many participants indicated

that it was unclear how these EOGs would interact with each other, with hospitals and public health officials” (Grossman, 1). Therefore despite the fact that a common communication system was established, all responders need to understand the role that a network control center plays during a response in order for efforts to not be redundant. A significant problem today manifests in the fact that “healthcare delivery systems, not to mention municipal public safety and public health agencies tend to plan and respond to emergency events as individual entities, not as part of a larger system” (Hanfling, 136). With individual efforts and response plans activated during a bioterrorist attack, a response will not be executed successfully—each agency and type of responder will be reacting in an individualized manner, and as a result many efforts will be either be duplicated or neglected and therefore not provided. Prior to a bioterrorist event “cooperative planning between healthcare organizations, and public health agencies, along with the remainder of the traditional first responder community including representatives from public safety and emergency management must become a cornerstone in the development of any comprehensive emergency response plan” (Hanfling, 136). A comprehensive response to bioterrorism integrates all potential first responders and receivers so that their efforts and skills are coordinated successfully, a line of communication is established and a viable response plan is outlined.

A Systemic and Architectural Response

Bioterrorism presents many strategic challenges for a systemic response that must coordinate the efforts between healthcare facilities and emergency response resources. In particular, the most significant systemic and architectural oversight remains addressing the needs of the walking well—victims who will present themselves for medical care both with and without symptoms consistent with exposure. During an event, these victims will greatly outnumber those who are in actuality symptomatic and potentially critically ill. The walking well were taken into account during the Topoff exercise:

“By the end of the exercise, on hospital had (notionally) seen an incredible 3,787 persons since the beginning of the exercise (only a few days earlier. Of these, some 3,200 were ‘worried well’—persons who did not truly have the pneumonic plague but were worried that they might have the disease of be developing it” (Inglesby, 441)

Furthermore, the Topoff exercise ‘did not address how healthcare facilities would distinguish between uninfected ‘worried well’, those with incubating or early

symptoms of plague, and those with other illnesses’ (Inglesby, 441). A response must take into account the potential of the walking well to inundate the healthcare system by providing a programmatic response specific to their needs, dispersed throughout any potential threat context and removed from the vicinity of healthcare facilities. A systemic and architectural response to bioterrorism—an unpredictable, low probability, high consequence event, must be systemic, dispersed, flexible and responsive to the variables of the walking well.

During a bioterrorist attack the response means and locations for delivering healthcare should be adaptive to the demands of the event variables presented. The delivery of care must expand beyond the conventional care setting, such as healthcare facility. During a bioterrorist attack “it is critical that the public understand that preparedness does not necessarily equate to availability of standard medical care during a disaster” (Hick, 8). Healthcare settings have a great potential to be isolated from the epicenter of attack. Unconventional resources and response settings dispersed in a decentralized manner throughout an urban context have a greater probability to better address initial needs of triage, diagnosis and information dissemination.

The most significant architectural response to bioterrorism is not redesigning existing healthcare facilities—they are not an ideal setting for dealing with the walking well. Based on resources available today, “the existing network of hospitals probably would not be capable of adequately caring for the people affected by a large-scale bioterrorist attack” (Glass, 4). Healthcare facilities are best equipped to spatially and programmatically handle the demands of critical patients. An architectural resolution is needed at a dispersed level throughout an urban context in order to catch and respond to the needs of the walking well before they present themselves at healthcare facilities, and inundate healthcare services needed by the critically ill.

During an event, existing emergency responders (fire, rescue, law enforcement, and responding medical staff) have the ability to directly assist in treating critical and non-critical patients. These types of responders must communicate with the established network of healthcare facilities in order to provide treatment to those directly in need of medical assistance. According to lessons learned during Topoff exercises, ‘to be effective and efficient, response to terrorist incidents should fully utilize existing systems, authorities and assets’ (National Response Team, 4). Furthermore, specialized typologies

of responders (such as HAZMAT and NMRT) are equipped to establish a response location at the epicenter of an attack providing decontamination, the distribution of medical resources for emergency responders to administer immunization and treatment to the critical patient population during an attack of bioterrorism. A response that prevents the walking well from inundating healthcare facilities and response locations (such as the epicenter or alternative care locations) is needed to supplement existing response efforts so that emergency responder are capable of dealing with critical patients. Response typologies such as public health information, self diagnosis, and wayfinding, should be distributed throughout a threat context, and be capable of activating without direct human assistance during an event so that the walking well are informed without the immediate assistance of emergency responders.

Communication of response efforts and responsibilities between healthcare facilities, and emergency responders should be coordinated prior to an event for a sufficient response to occur during a bioterrorist attack. This coordination will allow healthcare facilities and emergency responders the opportunity to be consistent and coordinated in their planning efforts and integrated in the manner in which they respond so that redundancy does not occur.

ESTABLISHING AND IMMUNE RESPONSE MECHANISM

Biological Metaphors in Architecture

Biological references can be relevant to establishing an appropriate response system or network and specific architectural interventions. A metaphor provides the opportunity for something established to be transformed and translated into an abstracted interpretation of the original subject. The use of (architectural) metaphors based in science provides an abundant source of analogies and inspiration. In reference to architecture and its relationship to modern science “is not the distance that separates the two disciplines but, on the contrary, a closeness that prevents free metaphoric exchanges” furthermore, “a productive metaphor needs an inherent distance between the terms that it links together—the clash in meaning being the source of resonance” (Lerner, et al., 119). Greater distance between the two subjects allows more room for interpretation when (architecturally) executing a metaphoric relationship. For example, the process of applying scaffolding to a building during construction or a re-constructive process is an abstracted metaphorical relationship to applying a (skin) graft to a living organism—a biological reference to the built form. It can be thought of as a reconstructive application to an existing object however it is not a literal interpretation of a scientific process. A metaphor based in science can serve as a basis for the establishment of an architectural theory not necessarily by mimicking the form but the manner in which something

performs. For example, the systemic response of antibodies can be translated to an architectural response to bioterrorism. Antibodies and architecture are not literally correlated and do not share a direct relationship. The manner in which antibodies are dispersed throughout a living being, and more importantly the way that they are reactive can serve as a model of systemic architectural response to bioterrorism. The concept of how antibodies function should be applied to designing a dispersed response to bioterrorism. This particular analogy should establish a correlation between how the subjects (architecture and antibodies) are reactive during an unpredictable event—a bioterrorist attack with any particular context, or an illness or invasion within the immune system of a living being rather.

Establishing a metaphorical relationship is a process that abstracts something absolute and formulates a conceptual idea. In this case the reactive process of antibodies is abstracted and translated to establish a systemic response to an event of bioterrorism within a physical threat context. The reactive conditions of antibodies and responders to bioterrorism are similar in that they are unpredictable in size, and location. The separation between their origination (science and art) and physical presence (internal

and external), makes establishing a metaphor between antibodies and architecture easier due to these differences. Architecture is not a static condition, but a dynamic process. Similarly antibodies are not stagnant, they are constantly reactive. A metaphorical relationship between the antibody system and architecture should be established to provide the basis for the development of systemic network and conceptual architectural interventions designed to respond to a bioterrorist attack.

Metaphor Typologies

Three typologies of metaphors exist: tangible, intangible, and a combination of the two typologies otherwise known as a combined metaphor. A tangible metaphor creates a strong, obvious connection between the analogy and the built form or its function. An intangible refers to a less evident relationship between the analogy and the product. Both typologies of metaphors are often executed architecturally to establish a purpose and meaning behind the built form--ultimately the architect materializes the relationship and role of the metaphor. Despite the fact that intangible metaphors are instituted upon a less apparent relationship, both typologies of metaphors can provide a strong relationship between the analogy and the built form when executed well. Utilizing



Figure 36, Casa Batlló



Figure 37, Casa Batlló

metaphors provides the opportunity to communicate additional meaning in a new context by translating and abstracting a known subject.

A tangible metaphor is a literal or visual metaphor that establishes a direct correlation between the analogy, form and function. For example if you build a hot dog stand, and adopt the form of a hotdog then people will recognize the function. The form is mimetic of the function or in some instances the metaphor itself. A successful example of a tangible metaphoric process is the works of Antonio Gaudi, specifically Casa Batlló in Barcelona, Spain. Gaudi's works were known for being organic, with strong references to natural forms. His works possessed an organic language that was achieved by abstracting natural forms. For example, the details of the window openings, and balconies were very skeletal in their appearance (Figure 36). The Casa Batlló is a good example metaphoric quality, exhibiting very strong visceral, skeletal and organic forms. Similarly, the details of the arched roof of the Casa Batlló were likened to the form of a dragon, or dinosaur (Figure 37). The works of Antonio Gaudi possessed tangible metaphorical relationships to natural and organic forms and establish a direct correlation between the analogy and the form.



Figure 38, Caltrans Building



Figure 39, Caltrans Building, Moveable Facade

A tangible metaphor such as the one previously described, will not be used to establish a response to bioterrorism. The proposed response locations (such as alternative care or existing healthcare settings) already exist within the fabric of an urban context—their physical envelope or form wouldn't need to be redefined to be mimetic of antibodies in order to respond to an event of bioterrorism. This typology is not relevant to establishing a response to bioterrorism.

An intangible metaphor refers to a contextual, less evident metaphor. An intangible metaphor, similar to a tangible metaphor plays with the image of a form; however an intangible metaphor plays on the hidden, discrete meaning of the subject or object. An example of this type of metaphor is the Caltrans (District 7) Headquarters designed by Thom Mayne and Morphosis. Home to the California Department of Transportation, the primary mimetic reference of this building is that of motion and transformation. Located in Los Angeles, this building is referred to as a part of the fabric of the city as opposed to being a singular, formal object. (Figure 38) The skin of the building is constantly changing. For example metal panels mechanically open and close depending on outside conditions such as sunlight and temperature. (Figure 39) Additionally,

the building materials promote visceral transformation. During the day the building appears to be a solid mass however during the evening the façade transforms (because of lighting) and appears transparent. Both of these systems integrated within the building envelope are mimetic of motion associated with the primary programmatic function of the building—transportation systems in an indirect manner. The Caltrans building and its mimetic reference to transportation is an example of a dynamic intangible metaphor—the building was designed with implicit systematic references to transportation and doesn't overtly mimic its subject in a static form.

For the purpose of this thesis an intangible metaphor will be established. An intangible metaphor can further be defined as “those in which the metaphorical departure for the creation is a concept, an idea, a human condition or a particular quality” (Antoniades, 30). An intangible metaphor will be used to establish a dynamic, systematic response to bioterrorism comprised of conceptual attributes that are mimetic of the antibody system. This type of relationship could also be referred to as an operative metaphor used to establish a connection between the antibody system and a systemic and architectural response to bioterrorism. A systemic response involves a series of components that are connected by an overall system. Metaphorically similar to the Caltrans building

and its skin that is active and responsive to environmental conditions, a response to bioterrorism should be controlled by activated response elements such as public health information and self triage linked by a communication network to one or more control centers (based on environmental conditions). Additionally, a response to bioterrorism should be active and adapt to patient flow—a response should not be static; it must be capable of a reaction dependent upon patient flow and demand during each unique event. Activation of a response to an event would be dynamic to the components associated with the event—type of agent used, number of people infected, and location of event, etc. An architectural response that looks to the antibody system is conceptually conceived to mimic the function of the immune system.

An analogy to antibodies is relevant to defining a (physical) response to bioterrorism; similar to a bioterrorist attack, the presentation of pathogens within the antibody system is unpredictable and requires an immediate form of response. The immune system has components that are programmed to respond in a way that collectively provides a response to a pathogen. An architectural and systemic response is made up of reactive components dispersed throughout an urban infrastructure, each playing a role in providing

a unified response during an event. An architectural metaphor can be established by translating the role and behavior of individual components of the antibody system into design strategies and architectural responses. Architecture modeled after the operative immune system can be more reflective of reacting appropriately to the unpredictability of various bioterrorist events. Analogous to the reaction of antibodies, a systemic architecture is a model of emergency response capable of meeting unpredictable and varied demands during a bioterrorist attack.

Antibody System Response

Components of the antibody system are integral within the body's overall defense network. The collective ability of the entire immune system establishes the capability of the entire system to perform as needed during a response. Each component has a role in preventing and protecting the human body against being infected. As a whole, the entirety of the system operates effectively because response capabilities are highly dispersed throughout an established network, in this case the human body. Architectural responses to an unpredictable event, such as bioterrorism should be mimetic of the responsive nature of the components that establish the immune system—a reactive, response network established with the ability to respond to unpredictable events within the human body.

An architectural response activated, controlled and managed at a remote location (by a communication network) would facilitate a response to bioterrorism with the ability to be highly responsive to the flow of patients during an event—similar to the manner in which the body is capable of responding to a disruption of the immune system. For

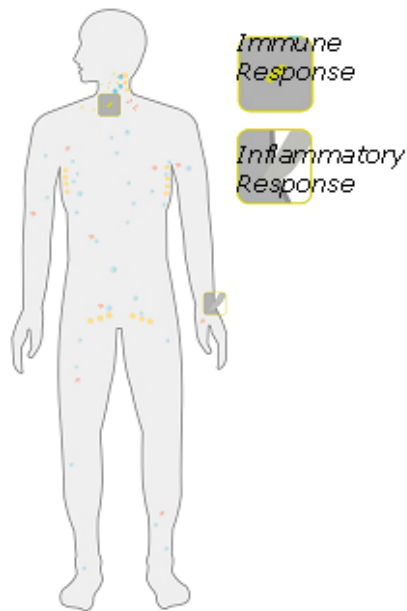


Figure 40, Pathogenic Response

example within the human body defense mechanisms are distributed and if a particular area becomes infected there is a means of neutralizing the foreign object or substance immediately regardless of the location of infection. A response distributed throughout an urban context has the potential to provide the same flexibility of response during an unpredictable event—if a portion of the city is attacked, there should be immediate response options within the event context capable of handling infected patients.

A correlation between systemic and dispersed architectural and antibody components within a large and variable response network sets forth the premise for a response to bioterrorism to be addressed. Analogous to the coordinated and variable response of the immune system, two types of response mechanisms—integrated and activated collectively reference the biological metaphor that will be used to establish a systemic context for an architectural response.

In the body, the exposure of a pathogen into the antibody system can involve two inherently different types of response—inflammatory (immediate recognition) or immune (delayed recognition). (Figure 40) The manner in which these different response

mechanisms are presented and recognized within the human body can be compared to the release and recognition of chemical (immediate recognition) and biological agents (delayed recognition) within an urban threat context. The antibody system activates once it recognizes a pathogen, a foreign element that invades the immune system. This is the metaphorical equivalent of a response to an event of bioterrorism within a threat context once an agent has been released or recognized.

In the body, an inflammatory reaction occurs when a foreign object (such as the contamination associated with a traumatic wound) enters a body—there is an obvious disruption to the immune system. The antibody system immediately reacts because the object entering the system contains (contaminated) pathogens that are easily recognizable. Symptoms become apparent immediately and require medical attention in addition to the natural antibody response in order to address the potential severity of the event.

In an urban context, the release of a chemical agent and the reaction that it evokes is similar to an inflammatory reaction within the antibody system. Identifying the

agent employed in a chemical attack can occur immediately because its presence is obvious—typically chemical agents have an odor or a color and can therefore be recognized easily. An immediate medical response should be delivered to victims once a chemical agent has been released. Decontamination, and other necessary medical services administered during a response to a chemical attack is similar to the immediate reaction of antibodies during an inflammatory reaction.

In the body, an immune reaction occurs when a pathogen presents itself within the body, yet remains unrecognized for several days. An immune reaction progresses slower than an inflammatory reaction because the pathogens enter into the system in a more indiscrete manner than pathogens associated with an inflammatory reaction. For example pathogens that present themselves when a cold or flu is developing, require this type of response. Not only do symptoms progress gradually, they are often more difficult to identify, however once the immune system recognizes them they begin the immune reactive process.

In an urban bioterrorism response system, the release of a biological agent within a context is similar to the presentation of a pathogen as when contracting a virus. Like

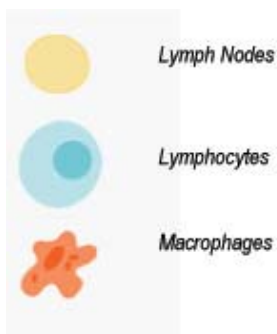


Figure 41, Continuously Present Elements

pathogens of an immune response, biological agents present themselves slowly, and indiscreetly. An agent is released within a context and often goes unnoticed for days until symptoms start to present themselves within their victims. Medical services are administered as well as antibiotics to prevent further infection once a biological agent has been identified. Similarly, once an agent is identified, the response network is activated. It is often difficult to identify the source of a biological agent, when and where it was released. The lack of ability to identify this type of agent is similar to a pathogen entering the body that requires an immune response—it is often difficult to identify the source of infection.

Components of the antibody system (in the body), and an architectural and systemic response to bioterrorism (within an urban context) are comprised of two basic typologies: those that are continuously present and provide a latent functions and those that are activated once a pathogen(or agent) is recognized.

In the body, continuously present elements of the immune system include lymph nodes, lymphocytes and macrophages (Figure 41). Continually present components of the



Figure 42, Integrated Network

antibody system are significantly similar to healthcare facilities and alternate care locations. In an urban context continuously present components of an architectural response can be thought of as an *Integrated Network*—locations that are always present within an urban context that inherently survey the condition of (public) health. During a bioterrorist attack, these components help to form the basis for a systemic response—acting as stationary, centralized elements. (Figure 42)

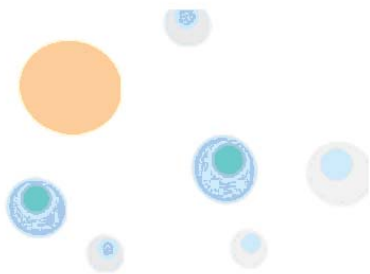


Figure 43, Lymph nodes and Lymphocytes

In the body, lymph nodes are stationary monitors dispersed internally throughout a body, close to the skin's surface (Figure 43). Lymph nodes monitor the status of the immune system determining whether or not it has been infected by a pathogen; lymph nodes act as a control center through which all the other components communicate with. For the purpose of establishing an analogy between the immune system and a response to bioterrorism the characteristics of lymph nodes that will translate to a proposed response are the capability of monitoring the status or presence of a biological, or chemical agent release, as well as the ability to serve as a control center for all components to communicate with.

Like lymph nodes in the body monitoring the status of a pathogen, the (existing and proposed) public health network within a context should be constantly surveying for pathogens (such as the flu, and viruses on a daily basis) that affect the population at large and would continue to monitor public health trends during an act of bioterrorism. The public health network, similar to lymph nodes (after a pathogen is recognized) would communicate with other proposed response components (and the public) to make them aware of the event. The proposed communication network that would link all types of responders (including healthcare facilities) together during a response effort is similar to the way that lymph nodes in the body act as a control center. Also comparable to lymph nodes, in an urban environment the proposed communication network (along with the existing public health network) would have the ability to monitor the current status of health throughout a context. When necessary (i.e. during an act of bioterrorism) the communication network would alert and activate the necessary responders, and response settings within the threat context; similar to lymph nodes communicating with the immune system when a foreign object (or pathogen) enters into the body's system.

In the body, lymphocytes are mobile components that are constantly present and

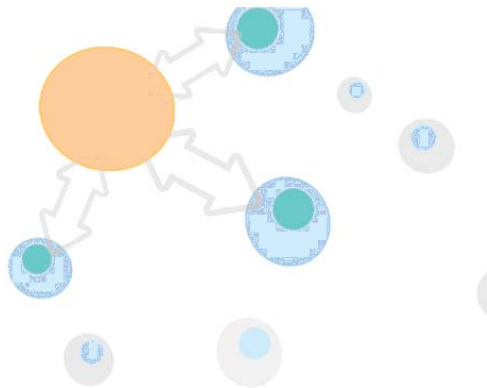


Figure 44, Lymphocytes Traverse

dispersed throughout the body. They communicate with lymph nodes (Figure 44) and react based on the demands of pathogens present in the immune system. When a pathogen is recognized by lymph nodes, the lymphocytes are alerted. In order to contain the pathogen, lymphocytes have the responsibility to transport the pathogen to a macrophage, a stationary component capable of pathogen containment. For the purpose of establishing an analogy between the immune system and a response to bioterrorism the characteristics of lymphocytes that will be utilized are the ability to be mobile throughout a context, the communication with lymph nodes and the reactive nature once a pathogen is detected.

Within an urban context lymphocytes are similar to emergency responders who have the capability to be mobilized such as Emergency Medical Responders, Law Enforcement, and Fire Departments. Similar to lymphocytes they are distributed throughout a context and accountable for providing a response to an event once it has been recognized. The communication network is capable of communicating with the emergency responders in order to activate a response in the same manner that lymph nodes communicate with lymphocytes once a pathogen is recognized. Analogous to lymphocytes transporting a

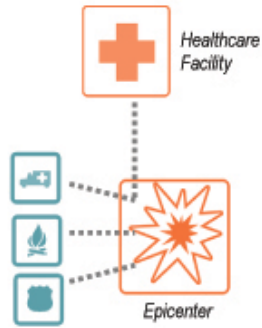


Figure 45, Urban Response

pathogen to the macrophages (in order to contain the pathogen) during response effort EMS (ambulances, etc) act as transporters of infected patients to a stationary component of the healthcare network. (Figure 45).

In the body macrophages are stationary components capable of containing a pathogen (once it has been recognized). Similar to lymph nodes, macrophages are located near the surface of the body (Figure 46). For the purpose of establishing an analogy between the immune system and a response to bioterrorism the characteristics of macrophages that will be utilized are the ability to be stationary (established) components capable of containing a pathogen (within a body).

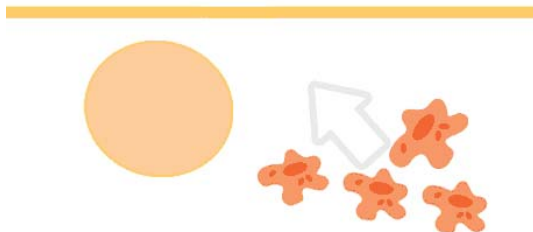


Figure 46, Macrophages

In an urban context macrophages are similar to healthcare facilities, stationary components within an urban context that are capable of surveying the condition of health based on the status of patients that present themselves (in particular to the emergency department). Once a patient enters into a healthcare facility, treatment is typically administered and similar to the function of a macrophage the disease or illness is defeated or contained. During a bioterrorist attack, hospitals would be utilized

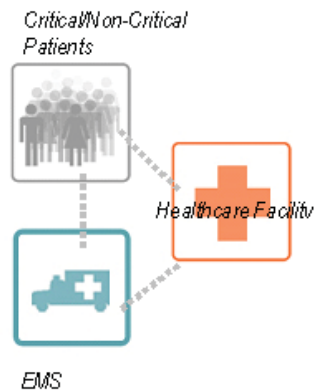


Figure 47, Healthcare Facilities



Figure 48, Antibodies and Antigens

to contain critical patients, ultimately with the purpose of eradicating a disease and preventing further infection. (Figure 47)

In addition to components that are constantly present, the immune system contains components that have the ability to be activated in response to a pathogen—antibodies and antigens (Figure 48). In an urban response context activated components establish the vocabulary for an *Activated Network* – locations that are dispersed throughout an affected or pathogenic area, but which serve latent everyday functions until the need for immediate and rapid response arises once the recognition of a pathogen has occurred.

Antigens are mobile components that remain dormant until they are activated and released by lymph nodes during a response. Antigens bind to the pathogen so that antibodies are able to recognize the pathogen. For the purpose of establishing an analogy between the immune system and a response to bioterrorism the characteristics of antigens that will be utilized are the ability to be inactive until a response (and activation) is necessary as determined by the lymph nodes (or the communication network.)

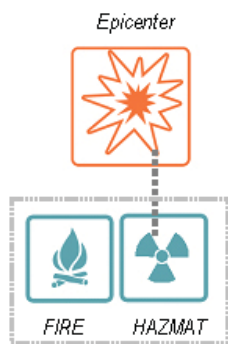


Figure 49, Specialized Response

In an urban environment antigens are similar to specialized forms of emergency response such as HAZMAT teams and NMRT. These responders are dormant on a daily basis, however during an emergency situation such as a bioterrorist attack, they are released by an existing (emergency) communication network and typically respond at the epicenter—the point in which the agent (similar to a pathogen) was released or recognized. (Figure 49)

In the human body antibodies are mobile components that are constantly being produced by our bodies in response to everyday pathogens that we come in contact with, as well as viruses that we have been exposed to. Antibodies are neutralizers that deactivate a pathogen. For the purpose of establishing an analogy between the immune system and a response to bioterrorism the characteristics of antibodies that will be utilized is their constant presence and ability to deactivate a pathogen.

In an urban context antibodies (within the body) can be compared to the proposed supplemental care locations that are established prior to a response. On a daily basis these settings such as schools, hotels, clinics, and arenas constantly perform their normal



Figure 50, Immune System Response

functions; however during a response to bioterrorism they are settings that can be converted to serve as secondary response locations primarily with the purpose to serve less critical patients (such as the walking well) so that the primary healthcare network doesn't become unnecessarily inundated. Unlike antigens however, these response resources are not mobile.

In the body, antibodies and antigens are capable of transporting a pathogen to the macrophages, where ultimately the pathogen will be destroyed (Figure 50).

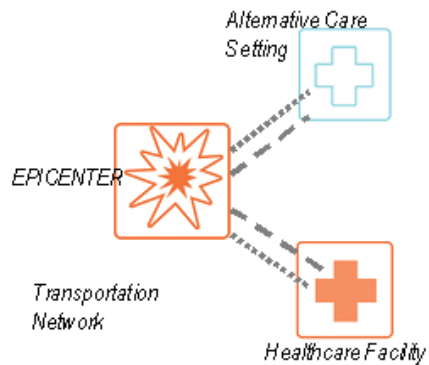


Figure 51, Adapted Public Transportation

In an urban context the combined function of both antibodies and antigens is similar to the proposed adaptation of the existing public transit network transporting patients to proposed and established care locations. (Figure 51) The transportation network within an urban context has the ability to assist in transporting patient to healthcare facilities or alternative care location to receive treatment.

Similar to the responsiveness of antibody components when a pathogen (unpredictably)

presents itself within the immune system, an architectural response to bioterrorism should also be systemic and flexible in order to efficiently respond to an act of bioterrorism. The components of the immune system are integral elements within the body's overall defense network. The function of each components assists in establishing the biological foundation that can help visualize and create a systematic response to bioterrorism that employs existing and new architectural and other health and emergency response resources.

This analogy to the human immune system defines a complete and systemic response to bioterrorism. In the body when a pathogen presents itself, its size, and location of recognition are unpredictable however an immediate response is required. These conditions are similar to the release of biological and chemical agents within a threat context—they type of agent used, as well as the size of the event and release location are unpredictable, however an immediate response is required. The design of the immune system allows it to respond in multiple ways that collectively provides a response to a pathogen. An architectural and systemic response should also be made up of reactive components dispersed throughout an urban infrastructure, each playing a role in providing a unified response during an event. A systemic model including both architectural and non-architectural resources analogous to our immune system is

an ideal model of reacting appropriately to the unpredictability of various bioterrorist events. Analogous to the reaction and performance of antibodies when a pathogen is presented, a systemic approach should be better capable of meeting unpredictable and varied demands of a bioterrorist attack.

RESPONSE PROPOSAL

System Defined



Figure 52, Activated Elements

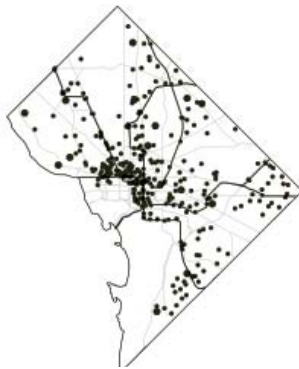


Figure 53, Integrated Elements

A response to bioterrorism must be systemic in its organization, and take into consideration potential resources and networks already in place within an urban context. Components of a response network include both activated (Figure 52) and integrated elements (Figure 53). Fundamental to providing a systemic response, “each (network) can be thought of as a potential conduit for organizing or facilitating public responses” (Glass, 3). Activated elements consist of smaller proposed architectural interventions (such as public health information terminals, and self-triage) located within the overall transportation network--at transit stops within the overall transportation network or elements within them. These proposed interventions would have a latent function on a daily basis and are located externally to healthcare facilities. These small scale elements include public transit nodes such as the metro rail and bus stations distributed throughout the context within Washington, D.C. During an event the network control center would be integrated to proposed elements (because of integrated technology) and would therefore have the capability of activating these response interventions within an urban environment; an opportunity to mitigate the walking well from healthcare facilities would be provided. Activated elements dispersed throughout the extents of a metropolitan context establish a network of many sites for the walking well to receive

information that they may otherwise feel necessary to seek at a healthcare facility. This will enable healthcare facilities to focus on providing healthcare to the most medically critical victims of a bioterrorist attack.

Integrated elements are comprised of established building typologies that can serve as temporary sites for the delivery of care to a large number of people. This would include small scale healthcare facilities such as clinics, and ambulatory care facilities, but could also include hotels, convention centers, and schools—places that are capable of adapting spatial resources to meet the demands of lower acuity victims and the walking well. For example during a natural disaster, The Red Cross assists in relief efforts by providing food, temporary shelter, and health services. Similarly during a bioterrorist attack public health information as well as some healthcare services will need to be delivered in these temporary response sites specifically to prevent non-acute victims from inundating health facilities designated for more acute care and isolation or containment of those actually needing these resources.

A viable response network must take into account the infrastructure of an urban context by utilizing elements that are easily identifiable and preferably have a widely recognized

civic identity in the community. Recognizable landmarks and elements of civic infrastructure used as sites for information, diagnosis and minor treatment can make these resources more accessible to those in need. Using existing building structure lessens reduces the amount of time and resources necessary to prepare a response with essential resources such as water and electric. During an event, “responders will have a limited window of opportunity to get things right” (Lasker, 2). The more defined a response plan is, the more responsive and effective responders will be. The purpose of a response network is to manage as best as possible response resources and patient flow therefore directing potential patients to the most appropriate site for their specific needs and condition. In addition to treating the acute and emergent victims of a given biological or chemical event, a coordinated response must include activated resources where potential victims can receive public health information as well as minor triage and treatment.

During an event, several types of response resources—both activated and integrated will need to be extensively identified and distributed throughout a threat context, allowing all potential victims the opportunity to be provided with healthcare according to their needs.

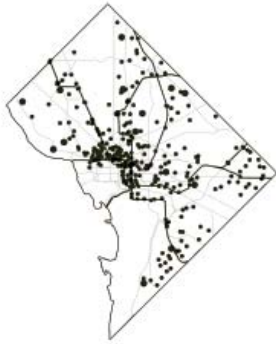


Figure 55, Integrated Elements

Integrated Response Network

The proposed integrated response network consists of established settings such as healthcare facilities and alternative care locations that have the ability to treat and inform large numbers of victims within the Washington, D.C. metro area (Figure 54, Figure 55). The proposed network provides a framework where various types of resources and settings for care can be administered during an event. Based on the location, numbers, and needs of the victims during an event, components of this integrated network can be activated accordingly. The most obvious elements within the integrated response network are healthcare facilities – including hospitals, clinics and other small facilities that are equipped with the necessary spatial and material resources to treat critical patients during this situation.

During an event, the proposed integrated response network is activated based on the demands of patient flow. Healthcare facilities or alternative care locations are activated accordingly so that a sufficient delivery of care is available as needed and dispersed throughout a context. Available activated clinics and other treatment sites throughout impacted areas during a bioterrorism attack would provide victims with less severe

injuries the opportunity to seek care, allowing major healthcare facilities to focus on critical victims. Dispersed diagnosis, triage and treatment sites throughout an urban context would allow victims—both real and imagined—with multiple opportunities to receive decentralized information and care as needed thus preventing any one facility from becoming inundated and not able to provide adequate care.

An integrated network cannot mitigate victims and the walking well appropriately without initial support provided by activated resources in the network. During an event, latent self-diagnosis and information elements would be activated at a highly distributed level throughout the city—in particular metro and bus transit stations—so that the general public would have many opportunities to come in contact them. Additional information would be available at these locations where appropriate care could be sought based on the degree of exposure. These elements would also provide wayfinding and information about alternative care locations and healthcare facilities so that the system could direct victims to appropriate care locations throughout the integrated network based on their self diagnosis.

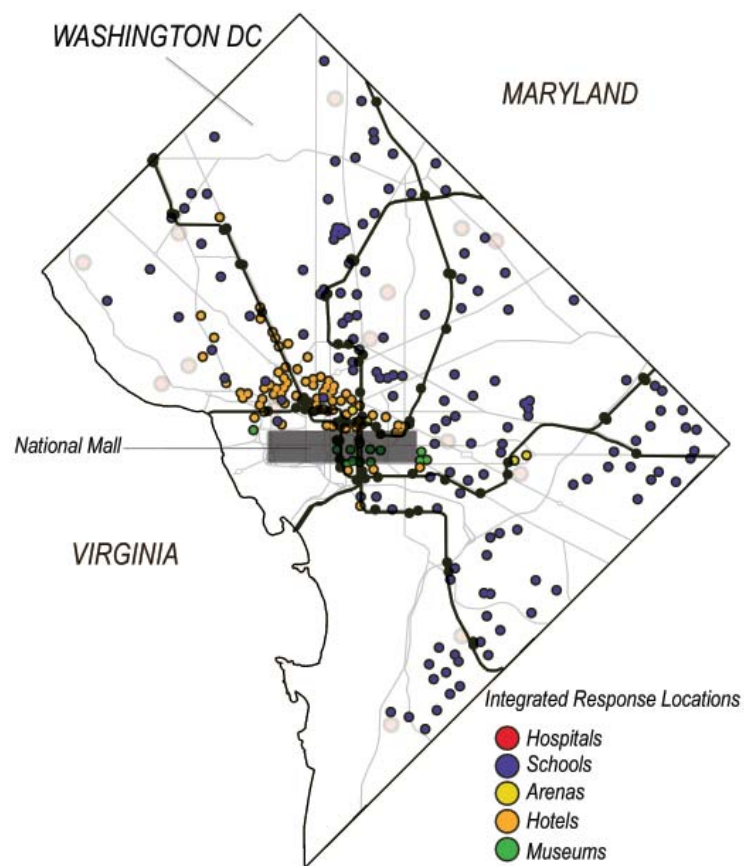


Figure 54, Integrated Response Locations within Washington D.C.

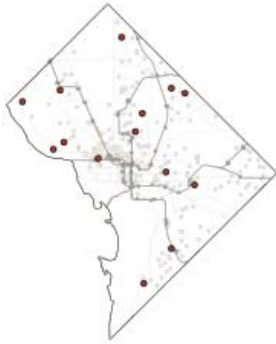
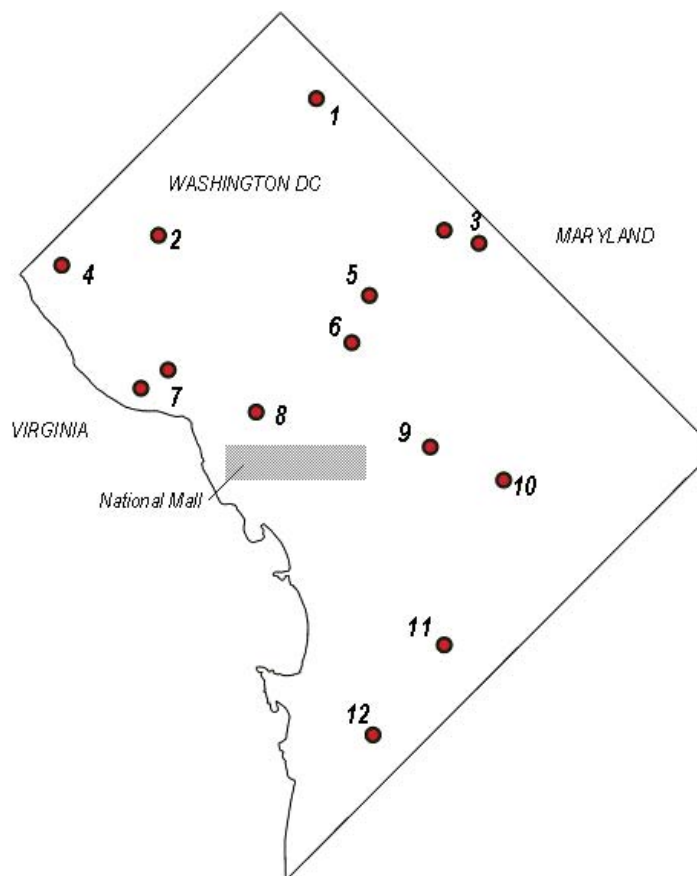


Figure 56, Healthcare Facility Network

Healthcare Facilities: The backbone of any integrated response network are existing healthcare facilities—including hospitals, clinics and other small facilities that are already equipped and established spatially and materially to provide a comprehensive medical response (Figure 56, 57). Based on simulation modeling of patient flow during an event, those patients in critical need of care would be directed to established healthcare facilities. In order to fully determine whether or not Washington D.C. is capable of handling the potential influx of victims from various scenarios an analysis of existing bed capacity and average availability must be understood.

Based on an informal assessment of existing healthcare facilities within Washington, D.C. it was assumed that no additional hospital-based facilities will be needed to supplement existing bed capacity. Existing healthcare facilities are adequately equipped, programmed and sized to handle the demands of critical victims as currently distributed throughout the entire urban context during an attack of bioterrorism. This assessment is based on the proposition that non-critical patients will be served outside of hospitals at established alternative care locations, and that the walking well will be mitigated through the activation of information interjections at transit nodes.

| | Beds | Average Occupancy | Average Daily ED Visits |
|---|--------------|-------------------|-------------------------|
| (1) Walter Reed Army Medical Center | 235 | 192 [43] | 55 |
| (2) Psychiatric Institute of Washington | 104 | 67 [37] | N/A |
| (3) Providence Hospital | 330 | 247 [83] | 94 |
| (4) Sibley Hospital | 226 | 162 [64] | 63 |
| (5) Washington Hospital Center | 834 | 625 [209] | 161 |
| (5) National Rehabilitation Hospital | 128 | 106 [22] | N/A |
| (5) Children's National Medical | 188 | 150 [38] | 113 |
| (6) Howard University Medical Center | 293 | 234 [59] | 119 |
| (7) Georgetown University Hospital | 283 | 178 [105] | 59 |
| (8) George Washington University Hospital | 231 | 155 [76] | 119 |
| (9) Medlink Hospital | 23 | N/A | N/A |
| (10) D.C. General Hospital | 150 | 97 [53] | 141 |
| (11) St. Elizabeth's Hospital | 609 | 584 [25] | N/A |
| (12) Greater Southeast Hospital | 278 | 183 [95] | 102 |
| TOTAL | 4,228 | 69 | 367,000 |



Facilities located in Washington, D.C. are capable of handling the predicted critical patient load during a bioterrorist attack.

Figure 57, Existing Resource Capability Healthcare Network

Alternative Care Locations: The secondary response sites of the proposed integrated network include locations such as schools, arenas, convention centers, and hotels. These sites must already be pre-equipped with spatial and strategic resources (such as water and electricity) and have the ability to be converted to handle the needs of potentially large numbers of non-critical patients (Figure 54). During an attack, presumably fear and panic will result in part because people are unfamiliar with this type of event; people will flood major transportation arteries in an effort to evacuate the city, as well as known healthcare settings in an effort to receive treatment that they might not need. Providing and directing people to additional activated response sites within urban infrastructures disperses opportunities for non-critical and the walking well to be diagnosed outside of centralized (conventional) healthcare facilities. These sites can help alleviate the load placed on healthcare facilities. An abundant number of potential treatment locations capable of responding can help re-assure the public that they will be able to receive care. Panic can be better addressed through a systemic and widely dispersed response at alternative care locations. The alleviation of fear can be made possible through the implementation of “a broad array of places—work sites, shops, malls, schools, day care centers, hospitals, clinics, cultural institutions, recreational and entertainment facilities,



Figure 58, Washington D.C. Hotels

government buildings, apartment buildings, and transportation terminals—serving as safe havens” (Lasker, 5).

Alternative Care Typologies: All alternative care typologies must have adequate plumbing, electricity (assuming no power outages have occurred) and shelter for the potentially large number of potential victims predicted based on simulation modeling prior to an event.

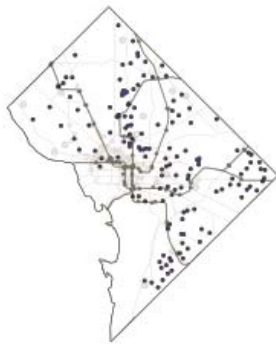


Figure 59, Washington D.C. Schools

Hotels: Given that they are already equipped with bedrooms and beds, hotels have the opportunity to provide intermediate care when hospitals are at capacity (Figure 58). A hotel would not serve as an immediate lower intensity inpatient point of care to non-critical patients; however patients who are in need of observation but not in critical condition could be transported to a converted hotel rather than hospital.

Educational Facilities: Schools are typically designated and equipped to provide shelter for large numbers of potential victims during a wide variety of disaster response scenarios (Figure 59). For example, a cafeteria, gymnasium or auditorium has the

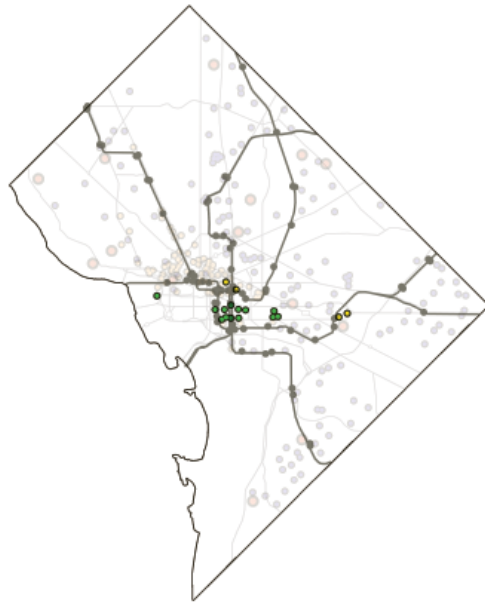


Figure 60, Washington D.C. Recreational and Entertainment

ability to provide a place of refuge for potential victims. Classrooms can provide smaller treatment areas allowing patients to be dispersed based on their level of need. The existing structure and organization of a school alleviates the need for responders to erect and establish temporary settings that otherwise would need to be provided.

Recreational and Entertainment Facilities: These settings such as indoor stadiums, arenas, etc are advantageous because they are designed to handle the flow of large numbers of people (Figure 60). Multiple points of entry provide the ability for many potential patients to be provided with shelter and care more immediately. Assuming that screening and triage capabilities were stationed at each point of entry, arriving victims could be directed to either further care or refuge. The biggest advantage to this type of building typology is the ability to house such an immense number of potential victims.

The predicted number of non-critical patients will be greater than critical patients that result during a bioterrorist attack. Similar to the response of the Red Cross during a natural disaster or other mass casualty situation, these alternative locations would be

served and equipped by disaster relief medical staff and other public health officials and volunteers. During natural disasters, the Red Cross is capable of responding with necessary medical supplies and staffing. Typically, this type of response takes place within existing infrastructure such as schools, stadiums or arenas. The proposed integrated network would be capable of activating in a similar manner—utilizing local staff and medical stockpiles.

Prior to an event, appropriate alternative care locations would be identified by a local jurisdiction; during an event, based on the location of an event epicenter and probable/actual victim flow, a variety of screening and treatment sites would be activated to serve non-critical patients and the walking well. Identifying these resources includes assessing spatial capabilities, as well as an estimating capacity level. Alternative care locations also must be sought out based on other basic programmatic functions—providing kitchens, bathrooms, and large waiting areas. In order to understand a generalized load capacity, building footprints were analyzed in the District of Columbia. The larger the footprint, generally the greater potential to handle a considerable patient load. Prior to an event square footage and capacity of probable alternative care locations would be

assessed by planning officials (and documented) to a greater degree. It is understood that “large spaces, such as cafeterias, or auditoriums can be used for observation of large numbers of patients with minor or not apparent injuries” (Macintyre, 146). The care delivered at alternative care locations would be less (medically) demanding and would be limited to non-invasive procedures such as the administering of immunization during an instance of bioterrorism. These alternative care locations would require no additional architectural modifications but would however require a supplement of medical resources and supplies. Most emergency response units are equipped with a stockpile of these resources to be utilized during similar situations in which care must be administered outside of a healthcare facility. During an event, not only would emergency responders staff a location, but medical supplies would be delivered to each alternative care location based on the type of care predicted to be needed.

Activated Network

During an event, a wide variety of potential response sites will be activated based on the relationship to the epicenter as well as the proximity to the greatest demand of victims. The number of responding locations would depend on the size, nature and impact of the actual attack. During a chemical attack it is predicted that a greater number of walking well will be generated within a closer proximity to the epicenter, therefore more alternative care locations will need to be activated to meet the demands of these potential victims; fewer locations would need to be activated further from the epicenter. Given the likelihood of an immediate recognition of the agent released, a response location would typically be established by hazmat teams at the immediate epicenter.

The release of a biological agent would demand a response that is dispersed throughout a context (at alternative care settings) due to the delay of recognition; a higher number of walking well are likely to present themselves across a much larger geographical area during this type of response because of the flu-like symptoms typical of biological agents. During either a chemical or biological event, dispersed architectural interventions that

convey event related public health information would be necessary to alleviate fear and panic throughout the potential victim population. Despite the type of agent released it can be assumed that the larger the epicenter, the more victims and walking well are predicted to be generated.

Staffing during an event would be based on available local medical staff not only including those within healthcare facilities, but (health department) public health employees. The activation of this temporary healthcare setting would require transportation of supplies to the alternative care locations—this can be performed by local emergency responders such as fire and other emergency responders. It can be assumed that ambulances will be consumed with transporting critical victims from the epicenter to the healthcare facilities, however other emergency response vehicles could be utilized to transport medical supplies from local stockpiles to alternative care locations. The network should only be activated to the degree needed to meet the demand and scope of patient typology and flow.

Services provided would include immunization and acute care services. For example

during a chemical attack or an event where trauma might occur during an explosion—victims needing only the dressing of minor wounds and abrasions would be treated at alternative care locations rather than at hospitals. Critical patients who may be in need of more invasive attention would be transferred to healthcare facilities where more acute services could be offered. Psychological services as well as public health information would be included at alternative care locations such as educational facilities, hotels, and recreational venues in order to better serve the walking well who would be directed to alternative care locations.

Post-event it is significant to restore activated alternative care locations to their prior use as promptly as possible once all care is rendered. Doing so provides the public with reassurance that life has returned to normal conditions. Educational facilities, hotels, and recreational venues should not be activated unnecessarily; they should only be activated when the demand of non-critical patients has the potential to quickly inundate the healthcare system. Post-event clean-up and sanitation must occur before a location can return to its normal function as quickly as possible. After containment and on-site treatment of victims has been completed following a chemical event, it is important

that the surrounding context of the epicenter be decontaminated so that any residual remainders of a chemical agent are removed from the exposed environment. This clean-up and restoration must take place to minimize environmental risk to people that live, work or need to move through the immediate area and in part to reassure the public that the subsequent return to normal use of these settings does not pose a health threat. It alleviates an element of fear and stigma associated with an event.

Potential victims, including the walking well would be made aware of all activated locations for care during an event through the placement of digital information displays at critical transit nodes and pathways including but not limited to Metro stations and highway message boards. These displays would convey public health information as well as media coverage of the movement of people within the city. Given access to accurate information on the event and where to seek appropriate help, potential victims would be more likely to seek care at the most appropriate accessible locations rather than inundating hospitals. Didactic interjections would also be visible at activated care sites prior to an event, similar to public service notices indicating the location of a bomb shelter. Therefore an appropriate awareness of a possible response sites can be

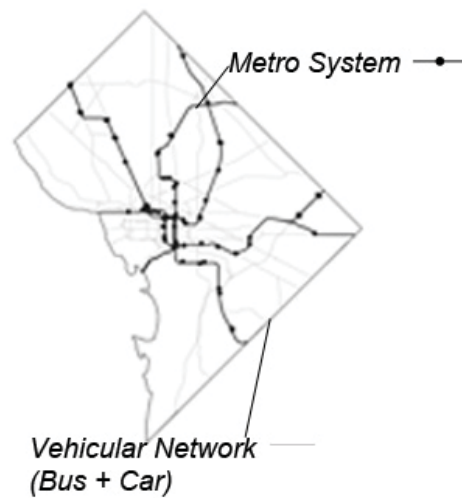


Figure 61, Washington D.C. Activated Transportation Network

made more apparent. If the general public is visually made aware of response elements and sites on a regular basis (prior to an event), then during an event they will have a general understanding of where to seek care.

During an event an urban-wide response is proposed through the activation of architectural interventions such as public health information terminals, thermal scans and self-triage kiosks and wayfinding features located within the public mass transit networks such as the metro system stations and bus stops. (Figure 61) These sites are located throughout the context Washington DC. The purpose of these activated sites and elements in the response network is to direct victims to appropriate care at many locations throughout the urban context before they seek care at, and inundate, acute healthcare facilities. Public health information displays and terminals would provide a cohesive information across the entire response network; information conveyed to the public would remain consistent and controlled by a single, response network control center. Activated elements such as thermal scans or self-triage kiosks within metro stations would function independently of each other; they are based on the immediate individual interaction of the general public including potential victims. The activation

of wayfinding elements at the street level would be dependent upon the activation of response sites surrounding the metro system. Wayfinding would only be activated if alternative care locations were functioning as care settings—the activation of care settings would be dependent upon patient flow generated by the response to self-triage. All proposed response elements would be connected to the network control center so that an overall picture of the evolving event impact can be understood and responded to appropriately.

A series of public health information terminals within the transit network would be designed and located to help disseminate public health information, and enable real and perceived victims to perform self-diagnosis through a series of health related questions. Self diagnosis could be accomplished through either small-scale architectural kiosks or by calling into a dedicated telephone system and answering a series of teleprompted questions. The series of questions would be designed to assess the patients current condition and determine the degree of care in which potential victims most likely need to receive. In addition to providing self-triage, this response can direct victims to appropriate location for care—a healthcare facility or an alternative care site. These

programmatic functions providing information, self triage and wayfinding can work effectively to serve a large number of potential victims due to the way in which transit networks are dispersed within an urban context, as well as their iconographic representation. Metro stations are generally known landmarks and nodes for residents, commuters and most of the people who live, work and move through an urban context. Through this didactic presence there is a greater potential for the walking well to have early access to front line information, diagnosis and referral. These elements may be used by any potential ambulatory victim, but will ultimately be able to meet the most immediate and appropriate needs of the walking well. Most victims however, won't know whether they are contaminated and need treatment or not until they engage the proposed diagnostic station elements.

Each component of the overall response network has its own responsibility and role, yet interconnects with the other as a part of the systemic response to bioterrorism. Activated elements, including both widely distributed diagnosis-information-referral sites and secondary treatment sites, together with established healthcare and emergency response elements are combined to form an integrated network. Activated resources are

designed to be the first point of contact with potential victims due to the high number of dispersed locations.

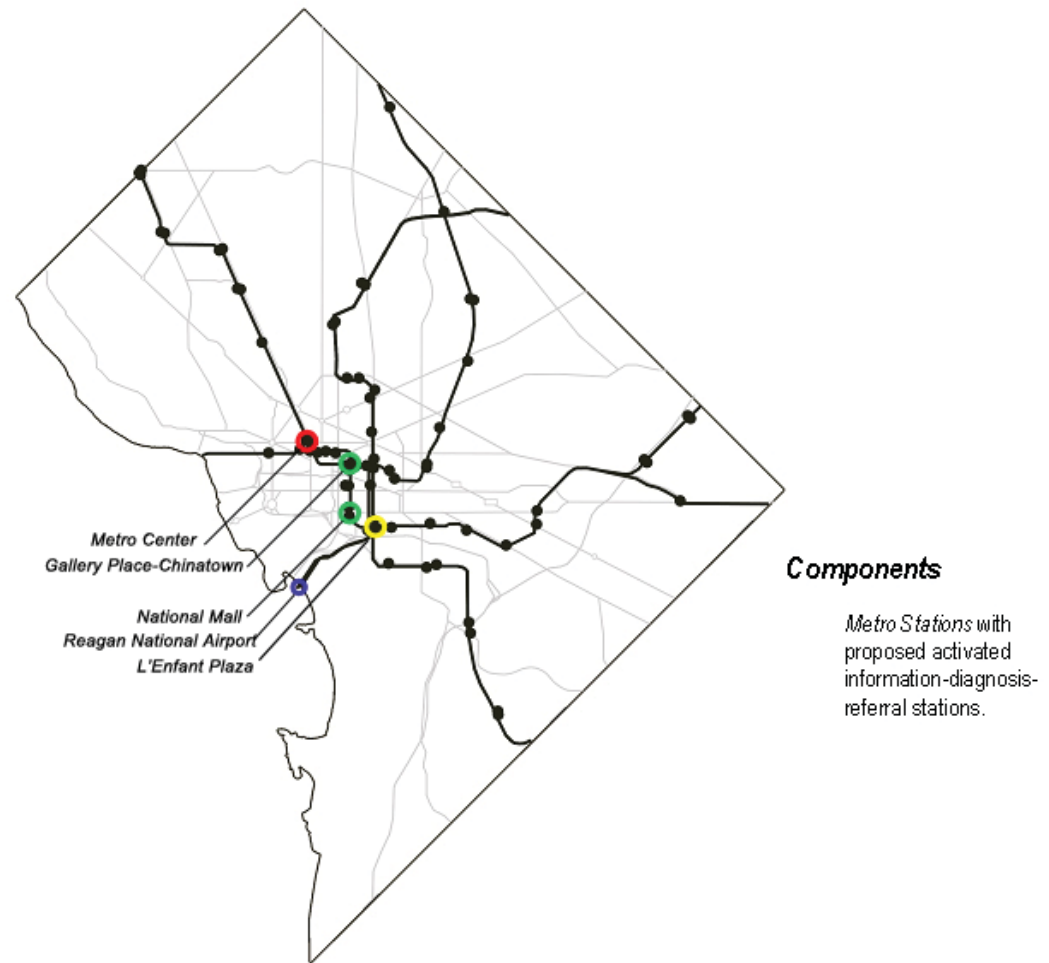


Figure 62, Washington D.C. Metro System Transportation Network



Figure 63, Metro System

Transportation Network: Mass transit systems are not only utilized daily by many potential victims but are also capable of transporting victims, both critical and non critical, to locations to receive care. It is plausible to assume that the use of “untraditional forms of transport may be needed because EMS assets will be challenged to meet the needs of the disaster” (Hick, 8). Urban transit systems, including metro rail systems, bus routes and the network of streets, will be used as principal components of the activated network. Bus or metro trains can be used to alleviate the predicted transport demand that will be placed on existing emergency resources, such as ambulances and other emergency vehicles. During an emergency response public transportation systems could be dedicated as patient transporters, no architectural intervention or physical change would be necessary. Rail mass transit systems are viable response models because they are scalable to the demands of patient flow —more trains can be added, or the direction of a line can change based on the location of event and care sites. Similarly, bus systems offer the same capability of being altered to meet the demands of patient flow however, they are much more flexible and less vulnerable to disruption than the rail systems. The nodes at which metro lines, bus routes, and street systems intersect establishes a series of potential transfer, control and potential triage

sites where potential victims can be sorted and transported as needed either by non-traditional or traditional modes of emergency response throughout an urban context. (Figure 62)

In Washington DC, the Metro not only serves the district proper but also extends into Maryland, and Virginia—therefore expanding the limits and scope of the potential response network (Figure 63). On average, the Metro carries 190 million people per year and provides the ability to commute to 41% of people working within the city (wmata.com). The fact that so many commuters rely on the metro on a daily basis establishes that the metro will be capable of acting as a ‘net’ during an event. If an event were to take place during a weekday, it can be assumed that while evacuating the city, a large percentage of commuters will come in contact with the metro—either the train or a bus. Therefore the transit system has the great potential to provide sites for disseminating information, serving as self diagnosis sites and redirecting the public as needed in responding to an event.

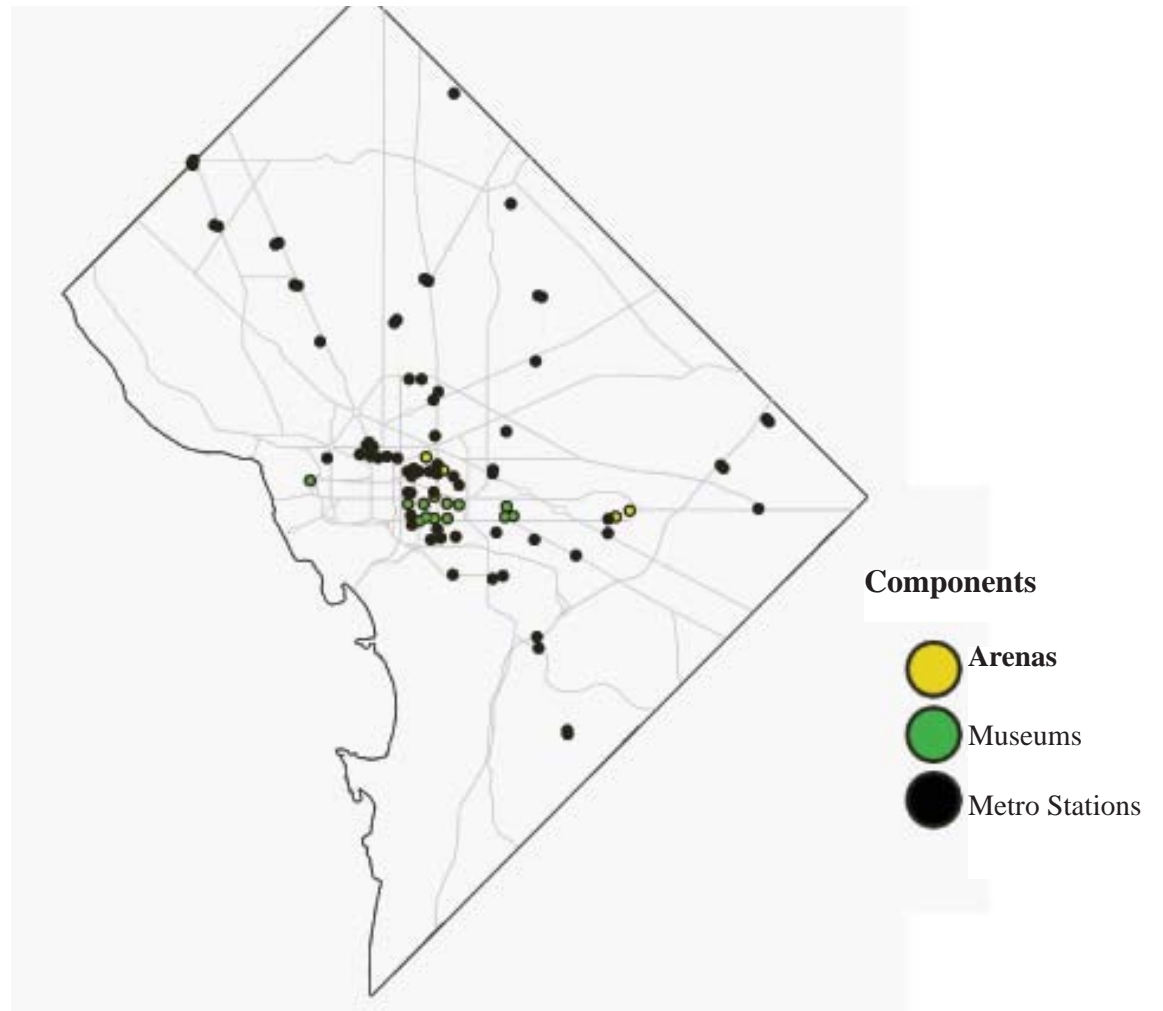


Figure 64, Washington D.C. Civic Nodes and Landmarks

Understanding that the mass transit systems are potential targets means that commuters within a targeted metro station would immediately be evacuated and treated at the street level in the event of an attack on a station or line. The metro would obviously no longer be able to serve as a means of transport during this type of event. In that situation the city bus network would be activated to transport non-critical and critical patients to healthcare facilities and alternative care locations. The bus system would also need to be re-configured to run routes that serve metro stops. Given the number of people who do not utilize mass transit – emergency vehicles must also become a part of the Activated Network. Commuters within their personal vehicles would be informed through digital street and highway signage and directed towards emergency response sites and resources along their route. Vehicular commuters could also phone into a dedicated system that allows them to self diagnose through an automated system. Utilizing all transportation networks within an urban context greatly increases the number of potential victims receiving public health information, or self-diagnosis through the distribution of activated elements during an event.

Nodes and Landmarks: In order to strengthen didactic awareness during an event, activated elements must take into consideration that a wide variety of civic nodes and landmarks possess a vital iconographic representation throughout an urban context. (Figure 64)

Transit nodes are established through the intersection of metro stations, bus routes, and the street grid, providing the greatest potential for reaching and transporting all types of potential victims, including both critical victims and the walking well (Figure 59). The mode of transportation utilized by each category of victim would be established particular to each event, the patient load, and the activated alternative care networks. Through planning and utilizing all modes of public transportation during an event, a flexible approach to response is established by providing various response options. For example, if the metro rail were to be targeted during an event, other options for transferring patients are in place. Response sites are identified by existing signage demarcating the entrance to a metro station, as well as a bus stop signage.

Within densely populated and heavily visited tourist areas some nodes and landmarks of iconographic representation may be unfamiliar to the visitor. Activated elements must be easily identified ‘points of attraction’ that a ‘tourist’ would recognize. These locations are significant not only because of their didactic presence, but because of the density of population that they typically encompass. Similar types of response, including self-diagnosis and public health information would be conveyed at highly legible landmarks throughout an urban context.

Design Criteria

The activated intervention selected for architectural study and development includes kiosks for public health information, self-diagnosis, and wayfinding. For a response to be implemented comprehensively based on the fact that bioterrorism is a low probability, hard to predict event design interventions dispersed throughout the city must have a latent everyday purpose in addition to an activated response after a bioterrorist attack. The basis for each designed interventions includes the following attributes: integrated technology, didactic representation, and the ability to provide a dynamic response. Each type of architectural interjection must be relatively low cost, widely dispersed, and have multiple latent and activated functions because the nature of bioterrorism means that an architectural or systemic response may be rarely or never actually needed in any given location.

Bioterrorism response sites must not only be minimum cost but also require nominal to no maintenance—preferably having a long shelf-life so that more locations can be widely dispersed and replicated through a threat context. A long shelf life reinforces the ability of a response to occur effectively regardless of the time that it remained un-

activated.

Integrated Technology: Integrated technology is the ability to provide a continuous and dynamic response to patient flow during a bioterrorist event with minimal human resources. Patient flow during an event will be fluid and unpredictable, design interventions have to be immediately reactive to this demand so that healthcare facilities do not become inundated with walking well. A response to bioterrorism should therefore have the ability to activate instantaneously and not be hindered by the inability of emergency responders (already at high demand) to deploy design interventions throughout an urban context.

Integrated technology is a covert component of the design criteria for a response to bioterrorism that occurs within the activated network and serves as a link between the programmatic responses—public health information, self diagnosis, and wayfinding. Integrated technology focuses on providing constant communication and information to the public during an event; emergency responders are alleviated of the task of directing or delivering information and services to potential victims at many sites



Figure 65, Deploying Airbags

during a response.

The activation of information-diagnosis-treatment sites linked through integrated technology during an event of bioterrorism is similar to airbags deploying within a vehicle (Figure 65). Multiple sensors, the controller and the airbags themselves form an integrated system that detects sudden changes in the state of a vehicle, including rapid deceleration and extreme physical changes. When conditional changes are detected the airbag is deployed automatically in order to provide a form of protection to the vehicles occupants. In a bioterrorism response system all interventions should be linked through integrated technology to an emergency control center. Once an event occurs and is identified by emergency responders the public must be provided with public health information, and sources of self-diagnosis and wayfinding. The emergency control center, located outside of the immediate urban context to reduce the risk of becoming a target of attack, would have the immediate ability to activate and/or deploy the necessary response interventions throughout an urban context. As the dynamics of an event change the control center would adjust the information conveyed to the public, as well as the number and location of activated design interventions.



Figure 66, Dynamic Responsiveness

Dynamic Responsiveness: Dynamic responsiveness is the ability for a designed intervention to react to the unpredictability of a bioterrorist event—specifically potential patient flow. Bioterrorism is unpredictable in nature; design interventions such as public health information, self-diagnosis and way finding, as well as alternative care locations need to be capable of activating in many ways. (Figure 66)

Dynamic responsiveness accommodates the need for various response models to occur based on the typology of an event; commercial aircraft are similar in that their emergency response features accounts for various types reactions to potential events. Planes are equipped with oxygen masks activated through a type of integrated technology that is controlled by a hierarchical network once conditional changes are detected. Likewise interventions dispersed throughout an urban context must be capable of activation without direct human response at the immediate deployment or activation location. Proposed design interventions would be connected to a command and control center through integrated technological devices and software. For example, human resources at a remote communication center would be able to activate responses through the use of software connected to individual elements within the transit network.

During an event a command and control center, comprised of various typologies of emergency responders, and medical professionals, would determine what dispersed elements would need to be activated based on the monitoring and dispersion of the agent and patient flow. For example during a chemical event it is immediately and physically evident where the agent has been dispersed and what the potential patient flow may entail—based on this information the control center would be able to determine where response components need to be activated.

During a biological event because of the delay in recognition the network control center would need to monitor patient demand and activate a response based on patient flow until more details are determined about the exact location of release. The network control center would be located remotely from the threat context, and would be both human, and computer-based. This center would be the main location for all typologies of responders to collect and disperse information pertinent to an event. In other words a widespread response may be necessary until details are established regarding the size and scope of a biological release. Once it has been determined where a biological agent was released then potentially exposed victims can be informed by the command and control center.

Another response analogy to be found in commercial aircraft are the flotation devices located under each passengers seat and emergency door (evacuation) slides. In the event of a survivable emergency event passengers would deploy their own device—direct human interaction is immediately needed for a response to be deployed. This type of response is analogous to the network of alternative care sites. Alternative care locations, such as hotels, schools, and arenas cannot serve as care locations without being activated and the direct response and assistance offered by emergency responders. Potential victim flow during a response to an event will be unpredictable in terms of the type of care and degree of assistance that will need to be provided. Dynamic responsiveness is provided by the reactive nature of both designed interventions and the alternative care network during an act of bioterrorism.

Didactic Awareness: Didactic awareness is the ability for a designed intervention to convey a cognitive awareness of response locations prior to an event. In an effort to alleviate panic, response efforts will be established at activated alternative care locations and nodes throughout an urban context external to healthcare facilities. During an event, an activated diagnosis, treatment and information sites located at recognizable



Figure 67, Fallout Shelter Sign

locations must be something that the public can locate and recognize.

The low probability, high consequence nature of bioterrorism implies that fear and panic will presumably result during an event. During the Cold War, fallout shelter signs (Figure 67) were employed to designate the location of shelters that had been identified, surveyed and pre-supplied to supposedly safe havens in the event of a nuclear attack. During any type of terrorist attack panic will be evident, however past episodic events indicate an overall sense of cooperation from the public. It is believed that “social chaos does not occur in disaster situations because people tend to respond in accordance with their customary norms and roles” (Glass, 3). During the cold war, shelter signs created a didactic awareness among the general public, and ultimately established an association with a place of safety. The uncertainty of what to and where to go can be alleviated if the presence of a response is established on a daily basis (prior to an event) in order to provide the public with further information regarding response strategies.

Another example of didactic awareness can be seen in fire alarm pull stations present



Figure 68, Fire Alarm

throughout public buildings. (Figure 68) There is a cognitive awareness of their presence and the response that they will provide during an emergency situation. During a response to an attack of bioterrorism, design interventions providing public health information, self-diagnosis, and wayfinding need to be deployed throughout an urban context. Similar to fire alarms, it is necessary for the public to understand their response and location during an event. Didactic awareness should be built into any fixed response location including components of the activated and integrated network.

DEFINING A RESPONSIVE PROGRAM

Program Components

The programmatic focus of this thesis proposal is on infrastructure elements dispersed throughout a threat context and designed to intercept, diagnose and redirect the walking well away from emergency departments and acute care hospitals. This thesis assumes that existing acute and critical care healthcare facilities can adequately handle the care of critical victims—therefore proposed program components do not need to include functions for critical victims that will presumably exist. It also assumes that non-critical victims will be treated at nearby schools, hotels, and other alternative care locations with sufficient spatial allocations as needed for an event. In some instances mobile resources such as EMS and HAZMAT teams will be deployed to some of these sites to compliment latent facilities and resources already in play. It can be understood that external supplies will be provided by pre-positioned and dispersed stockpiles, such as those established by the National Metropolitan Response Team (NMRT), or the Centers for Disease Control. When establishing the response program components, healthcare facilities and alternative care locations need no further architectural attention beyond existing spatial and resource allocations.

Each designed element proposed within the response program has two types of

functions—latent and activated. Public health information would be made available during both normal day-to-day use and during/after a bioterrorism event, however the information conveyed would be pertinent to the status of the event and direct people how to react. Metro ticketing terminals will latently serve in their normal capacity for riders, when activated they will have the potential to be converted into self diagnosis stations, providing potential victims with the opportunity to triage themselves. Conditional wayfinding elements and signage located at the street level would have the ability to be digitally converted during an attack and have the capability to direct non-critical victims to a dispersed alternative care locations. All three program responses are interconnected to a network control center and event management centers through integrated information technology.

Network control center: A network control center establishes a non-architectural connection between designed interventions and emergency responders. The existing and proposed network control center must provide information and continuity between dispersed program/system elements during the entire timeline of a bioterrorist event. Components must be interconnected through the use of technology to the network

control center so that an appropriate response is based on specific event typology and patient flow. Technology integrated within each program response enables responders the ability to monitor event impacts and patterns of infection/contamination and relay immediate, up to date information to all elements in the system during an event.

Most healthcare facilities currently have a designated emergency response center. Typically these response centers have an established connection to external emergency responders, such as EMS responders as well as fire and other types of local response units. The intent of a control center within a healthcare facility however is to provide consistent, ongoing response and monitoring of onsite resources during an emergency situation. Therefore each healthcare facility currently functions as an isolated entity throughout an urban context and does not comprehensively take into consideration response efforts being made at other potentially impacted facilities. Multiple hospitals functioning as an individual emergency responder creates the potential for redundancy of resources, lack of coordination and a less effective response during an urban wide event.

This thesis assumes a proposed communication and coordination network that would include a centralized response center (determined prior to an event) outside of the threat context that would coordinate all emergency responders, public officials, representatives from healthcare facilities and medical staff collectively so that they have the ability to act as a single entity. The intent of a central response location is to provide and monitor a distributed response based on resources and patient flow throughout an entire urban context. The specific location of a centralized response center would be based on the size of an urban context and available resources located outside of a particular threat context. A centralized response center does not necessarily need to be designated within a healthcare facility, but rather could be located in an alternative care location. Within the context of Washington DC, federal representation and authority would take precedent due to the potential threat targets such as the White House, Capital, and other major Federal Institutions. Despite the role of the federal jurisdiction, local responders would play a key role in providing care during a bioterrorist attack. All responders within the coordinated network would monitor the situation, provide status reports and receive coordinated directives thus determining the type of response needed and where it needs to take place.

A control center would be staffed by representatives of each organization and jurisdiction in the response network therefore establishing a sense of continuity during a response. In addition to conventional medical staff and emergency responders, other representation would include public health official and media responders who would be present within the control center. “Hospitals would need to communicate with and receive support from a wide variety of organizations, including other hospitals and local, state and federal health officials, as well as emergency management and public safety agencies” (Inglesby, 443). The proposed control center and network control center would be activated immediately, so that critical decisions would be made as to what programmatic elements would be activated as necessary, and information would be conveyed to the public to respond accordingly and alleviate panic.

Panic and confusion can be minimized by providing consistent and accurate information to the public during a disaster. During an event “the release of inaccurate, confusing or contradictory information by leaders and/or the media has the potential to increase levels of fear, panic and demoralization as well as to discredit authorities” (Glass,

4). Typically during any type of episodic event media representation can not always be considered as a complete and accurate representation of the actual situation. The media has the opportunity to play a major role in notifying the public appropriately during a bioterrorist event if media sources are directly a part of the central response center. They would be informed immediately by authorities within the response center and would serve as one information conduit for the control center, directly informing the public. It is essential that the central response center establish “a close working relationship between (the media), decision makers and those involved in response operations” (Glass, 5). Due to the mobile nature of occupants within an urban threat context, widespread access to health related information beyond the capability of existing system notification elements within the transportation network is necessary in order to provide the most opportunities for potential victims to gain information about a bioterrorist attack outside of the immediate urban threat context.

Public Health Information Display Elements: Multiple types of information should be conveyed to the general public throughout the (urban) threat context—“healthcare staff should provide information on the agent involved, potential short- and long- term effects,



Figure 69, Display Element



Figure 70, Metro Display Panel

recommended treatment, stress reactions, and possible avenues to further assistance” (Macintyre, 246). Public health display elements would provide information both preceding, during and post- event. (Figure 69)

Public advisory display elements would be located throughout an urban context—specifically within the transit network, streets, highways and other movement pathways. Display elements would be integrated within buses and bus shelters (street level) as well as on trains and metro stations (below grade). These display elements would be operated on both an activated and latent basis and would therefore not only be used during an event. Currently within the metro system there are display panels at the train platform informing the public of arrivals and system information. (Figure 70) These elements are controlled through the use of technology at a single location. Similarly, public health displays would be technologically integrated to the network control center. The health content displayed on a latent basis would be decided upon by a public health representative. Display panels could also be individualized allowing information to be tailored to the needs of a particular area. For example panels near the event epicenter would need more specific information during a response compared to

information displayed further away from the epicenter that may only give an alert that an event has occurred.

Non-event public health information would provide information useful to the target population, or cover current health trends. During flu season for example, public health information could provide users with information as to where to receive a flu shot. Similarly, within the District of Columbia the potential opportunity for a bioterrorist attack is measured by a threat level indicator (dictated by the Department of Homeland Security). Once the threat level reaches a high threat indication the display element would convey security measures that the public need to take, or be aware of.

Activated public health display elements during an event would provide potential and actual victims with the opportunity to receive information pertinent to the type of incident that has occurred (i.e. what symptoms occur when a patient has been exposed to anthrax, or how is an agent spread from person to person). Emergency response representatives within the network control center would collectively decide what information should be conveyed to the public. More significant is the fact that

information could change instantaneously based on the status and impact of an event.

A network comprised of “systems and protocols for communicating timely and accurate information to the public are critical during crisis or emergency situations” (NIMS, 28). Providing information to the public establishes a sense of control at the victim level during what may seem like an uncontrollable event. Similarly, health information conveyed at a dispersed level would provide the walking well with the information they would otherwise seek from healthcare officials and facilities.

Independent-Triage: The general public should have the ability to independently perform an initial form of self triage during an event response. Potential victims will want to seek immediate answers as to whether or not they are infected. The impact of the walking well can be tempered through a series of opportunities for independent triage (including thermal scans and self-diagnosis kiosks) dispersed throughout a network of mass transit stations and nodes. Establishing independent triage sites throughout a context will assist in coping with the potentially widespread impact of a bioterrorist event.

Washington D.C. is in the process of implementing an automated independent triage system through an electronic assessment either via phone or internet. This system is comprised of a series of 'yes/no' questions specific to the symptoms that a victim may be experiencing due to the exposure to any type of bioterrorist agent. When performing a individual assessment "after the computer leads someone through the questions, either online or over the telephone, the patient would be advised according to what the symptoms seem to be. The options the system might offer include: stay at home in voluntary quarantine, go to a designated site for follow-up care, move to an isolation facility or just relax" (Goldstein, 1). During a time in which medical staff will be at high demand, this type of system provides a greater sense of security to the walking well because they are able to receive an answer much more immediately than otherwise possible. An electronic self triage system is a viable means of providing triage extraneous to a healthcare facility without direct assistance from medical staff. This system is a comprehensible and practical means of response, however it only targets individuals with access to a phone, or the internet—those who don't have that access to these amenities need to also be served.



Figure 71, Thermochromic Material

Potential victims who do not have access to either a phone or the internet can be served through the dispersion of independent triage stations throughout a threat context. The number of triage stations needed to provide an opportunity for individual triage can be based on the average number of people typically present on a daily basis within a given context that may not have access to a phone, or the internet. There are two types of independent triage that are technologically available and can be implemented extraneous to the telephone/internet method of diagnosis – thermal scans (Figure 71), and self-diagnosis kiosks. Thermal scans provide a quick generalized diagnosis that ultimately serves as a filter, sorting the actual victims from the walking well. Although a slower response, self-diagnosis stations would supplement thermal scans and would provide a more detailed level of assessment. These kiosks could be located at a wide variety of locations throughout an urban threat context including transit nodes, gas stations, rest stops, etc.

The process of individual triage through the use of thermal scans involves checking a basic vital sign—in this case body temperature. Thermal scans operate in a manner that



Figure 72, Thermochromic Display Element



Figure 73, Ticketing Vending Terminals

once a user comes in contact (by touch of the hand) with the thermochromic material, the surface (after a few seconds) will change color based on the temperature of the user's body. A common side effect for patients who have come in contact with predicted types of biological or chemical agents, is elevated body temperature. Thermochromic surfaces can be regulated to be reactive only to temperatures that would classify as a fever. A user will visually receive either a positive or a negative reaction. (Figure 72) Coding could be printed onto the thermochromic surface explaining the translation of color and temperature range. The surface would also display additional instructions similar to the telephone/internet responses. If in fact they have a fever, they would be directed to a nearby self-diagnosis station typically located within a close proximity to a thermal scanner.

It is proposed that within proximity to thermal scans, (latent) ticket vending terminals within a metro station would be activated during an event, and converted into self-diagnosis stations. (Figure 73) Prior to an event, software would be implemented into the terminals to provide the necessary response during an event. When using a self-diagnosis terminal, the user would also be thoroughly questioned about the state



Figure 74, Wayfinding Elements

of their health, similar to typical questions asked by a triage nurse at a healthcare facility. Ultimately a form of electronic assessment “would ease pressure on hospitals” (Goldstein, 2). The self diagnosis process would also act as a means of collecting public health information—particularly patient information and tracking, allowing responding authorities to survey the pattern of disease and victim flow.

Wayfinding Elements: Wayfinding elements (Figure 74) must be provided to help people navigate to healthcare settings such as hospitals and activated alternative care locations once they have received the results of an individual triage assessment. These elements will be integrated or attached to existing infrastructure elements in the urban fabric such as light poles, traffic signals, electronic highway advisory signs, billboards, transit signs, etc. The wayfinding system targets all users, but in particular those who may be unfamiliar with appropriate care locations. Potential victims unfamiliar with their environment may be less likely to successfully find alternative care locations compared to local residents. In addition, wayfinding as a response program component can help alleviate fear and panic by reassuring potential victims of their ability to locate appropriate care settings.

Wayfinding must occur at two separate levels—underground (within the metro transit system) and at street level. Similar to the way in which public health information is distributed, a connection to a coordinated response network would be established and would control the information conveyed to the public based on the scale and location of an throughout an urban context. The adaptation of existing information devices on both levels of an urban context would provide all potential scenarios and users with information that would direct them to care locations. In addition to directing possible victims on foot, wayfinding should be located so that those in vehicles can also obtain direction.

Information displayed to potential victims would identify the location of activated healthcare facilities or alternate care locations within proximity to the self-triage kiosk. Wayfinding would provide a type of mapping, and visual queue for patients, establishing opportunities for them to be directed to care locations assigned by their self-triage diagnosis during an event during which they may be overwhelmed with unnerving emotions. All wayfinding components would not be utilized at once; patients shouldn't



Figure 75, Digital Signage

be directed to contexts (alternative or conventional healthcare settings) that are not activated. Wayfinding is established through a minimal architectural interjection capable of being used on a latent basis (to convey public health information, or information regarding events throughout the city). Digital signage located above ground would have the ability to be powered by solar panels, similar to the way in which many street lamps function today. This would therefore allow the continuous operation if the power grid was disrupted.

Wayfinding located within the metro system would occur through the adaptation of information displayed on existing digital signage (Figure 67) located at the train platforms. As previously noted, this signage would also be used to convey public health information. The adaptation of existing signage would occur through the use of integrated technology with an established connection to the network. The remote network of emergency responders would determine the need for metro (trains) to be used as a type of medical transport. When not commandeered by response authorities specifically for medical transport, it can be assumed that less critical victims or those who can be served at an alternative care location would be appropriately directed to

designated trains and buses to travel between their individual triage and the location where they will be treated depending on their need for isolation from the general public. Critical victims would presumably need medical assistance and may need to rely more heavily on emergency responders. Those victims independently moving toward care locations would need signage on the street to direct them from the metro stop to the appropriate setting to receive care.

Wayfinding that occurs at the street level would be critical during an event in which the underground metro system was the targeted site and potential victims could not rely on Metro trains for transportation. When the metro system is unable to act as a component of the response network, the bus system would be utilized instead. Wayfinding is equally as important during this type of scenario due to the fact that more people will be traveling by foot and will need the assistance of (digital) signage at street level that would provide direction.

IMPLEMENTATION OF PROPOSAL

Study Area



Figure 76, Metro Iconographic Signage



Figure 77, DC Metro System Map

Through the utilization of the existing mass transportation network and its supporting elements, this proposal for a systemic and architectural response to bioterrorism in Washington, D.C. will focus primarily on the identification and development of architectural and programmatic interventions including public health displays, independent triage terminals, and wayfinding elements. Dispersed throughout the mass transit system, these interventions are designed to supplement existing resources and to provide the walking well with services that they would typically seek at a traditional healthcare setting therefore reducing the potential for non-critical victims during an event to inundate typical care environments.

The transit network, specifically the metro rail system (Figure 76, Figure 77) in Washington D.C. is an icon and has established nodal conditions throughout the D.C. area. As a result of the conditions for which they are designed, public mass transportation systems have the ability to handle the ebb and flow of large masses of people; these types of systems are also capable of managing changing passenger flow during peak hours. Increased numbers and more frequent trains can accommodate a larger number of customers during rush hour, as well as the ability to change the flow of turnstiles

to meet the demands of riders entering and exiting stations. For example, during rush hour in order to meet the demands of the flow, stations at the end of a rail line convert the majority of their ticketing turnstiles to allow more riders to exit a station than enter; the opposite condition would occur at these stations in the morning rush hour. During an event it is critical to be able to adapt a response context based on the demands of both predicted and unpredictable victim flow.

Distributing a response to meet the needs of the primary victim typology, the walking well, throughout an urban context alleviates the potential for these patients to seek unnecessary care at traditional healthcare settings. The metro system has the ability to function independently as a type of response without immediate assistance from an emergency responder. This component of the transit system however would need to be controlled from a hierarchical remote point of response at the communication center defined previously within this thesis. Utilizing an existing system during a response to bioterrorism that is capable of handling large numbers of people on a daily basis allows the focus of the healthcare provider to center around critical and non-critical victims rather than having to focus on managing and filtering the needs of the walking well.



Figure 78, Corner Condition Entry



Figure 79, Plaza Condition

Metro Station Typology: Metro stations located throughout D.C. commonly have two basic configurations that are defined by their entrance location—a corner condition or storefront condition of a building façade that is open at grade to the sidewalk (Figure 78) or within an open plaza area (Figure 79). Typically, when a building façade entry occurs, there is a limited covered space where response interventions and efforts can take place due the minimal sidewalk space. Open plaza conditions are more spacious and allow for a more generous opportunity for response; however, there are not many of these entrances throughout the network.

The progression of a rider through a Metro station occurs at three basic levels—entry, ticketing and platform. At each of these levels an architectural interjection is proposed as a model of response during a bioterrorist event. As a victim progresses through the metro station during an event the programmatic response present, such as individual triage, is tailored to the symptoms related to the type of agent used during an attack. This type of filtering should occur so that actual patients are directed to appropriate healthcare or alternative care location, and ultimately so that the walking well do not disrupt the



Figure 80, Ticketing Terminals



Figure 81, Metro Ticketing and Entry Turnstiles

ability of responders to provide care for those in need of medical treatment.

At the (street) entry level, this thesis proposes that public health display elements be integrated into the fabric of the metro station and serve both an everyday latent as well as an activated function during an event. Also at the entry level, the initial point of independent triage would occur and include thermal scans. It is necessary to provide both of these architectural and programmatic interjections at the entry level so that the walking well are given the opportunity to determine whether or not they have symptoms and need to seek further treatment to prevent them from inundating a metro station.

Ticketing areas typically include multiple independent ticketing machines (Figure 80), a station operator kiosk (with a metro employee present) and turnstiles that allow riders to progress to the platform levels. (Figure 81) This thesis proposes that the second stage of independent triage, self-diagnosis takes place at this level through the adaptive reuse of ticketing terminals. The number of ticketing points available within a Metro station depends on daily utilization as well as the number of rail lines that are present within a station. This thesis assumes that the existing number of terminals will be



Figure 82, Entry Turnstiles

adequate during a response effort. Information technologies are already in place with existing metro stations; during an event a proposed response (such as self-triage) would piggy-back on to those components (by converting internal software systems). In case of an event, the existing metro system components and functions (such as the ticketing terminals) would be overridden and controlled by the network control center. Once a potential victim has completed the self-diagnosis process they would receive a ticket with their information and diagnosis. The ticket would not only have a summary of their assessment but a specific treatment location would be identified so that the victim would know where to seek further care. The machines used for this process would be modified versions of the ticketing machines currently used in the metro and would be able to issue regular metro tickets during normal conditions.

Likewise the turnstiles (Figure 82) that allow entry into the metro system would also be replaced with adapted versions that serve both a daily function and a modified function during a terrorist event. Entry turnstiles are a controlled component and the number of them in any given station is based on the size of the station. The direction in which people can use them varies pending on the time of day and the demands of the flow of



Figure 83, Platform Signage

traffic. This thesis will assume that an adequate number of turnstiles needed to handle the volume of people are provided. Under event response conditions after a victim has been assessed at the modified ticketing machines they would insert their ticket into the turnstile tickets to enter--only patients that need additional medical care would be able to enter into the metro system. This process helps to prevent the walking well (who do not require further medical attention) from entering into the metro system. Only those victims with an appropriate diagnosis could proceed into the metro and use the adapted system accordingly.

Once at the platform level, riders are directed to their trains through the use of digital signage. (Figure 83) During a response effort, station signage would be converted to provide wayfinding and public health information—for example it would inform identified victims of the platform that they need to be at in order to travel to a particular healthcare facility or alternative care location. This signage would specifically convey information about which healthcare facilities and alternate care locations are activated, where they are located and what trains would be servicing those locations. Correspondingly, once a victim has arrived at the (destination) station serving their

respective healthcare facility or alternative care site, appropriate stations signs would also be activated to provide wayfinding from the platform to their destination. At the platform level thermal scans could be activated only during instances where patients exiting trains were believed to have been exposed to an agent; during all other cases public health information and wayfinding would be the primary means of response at the platform level.

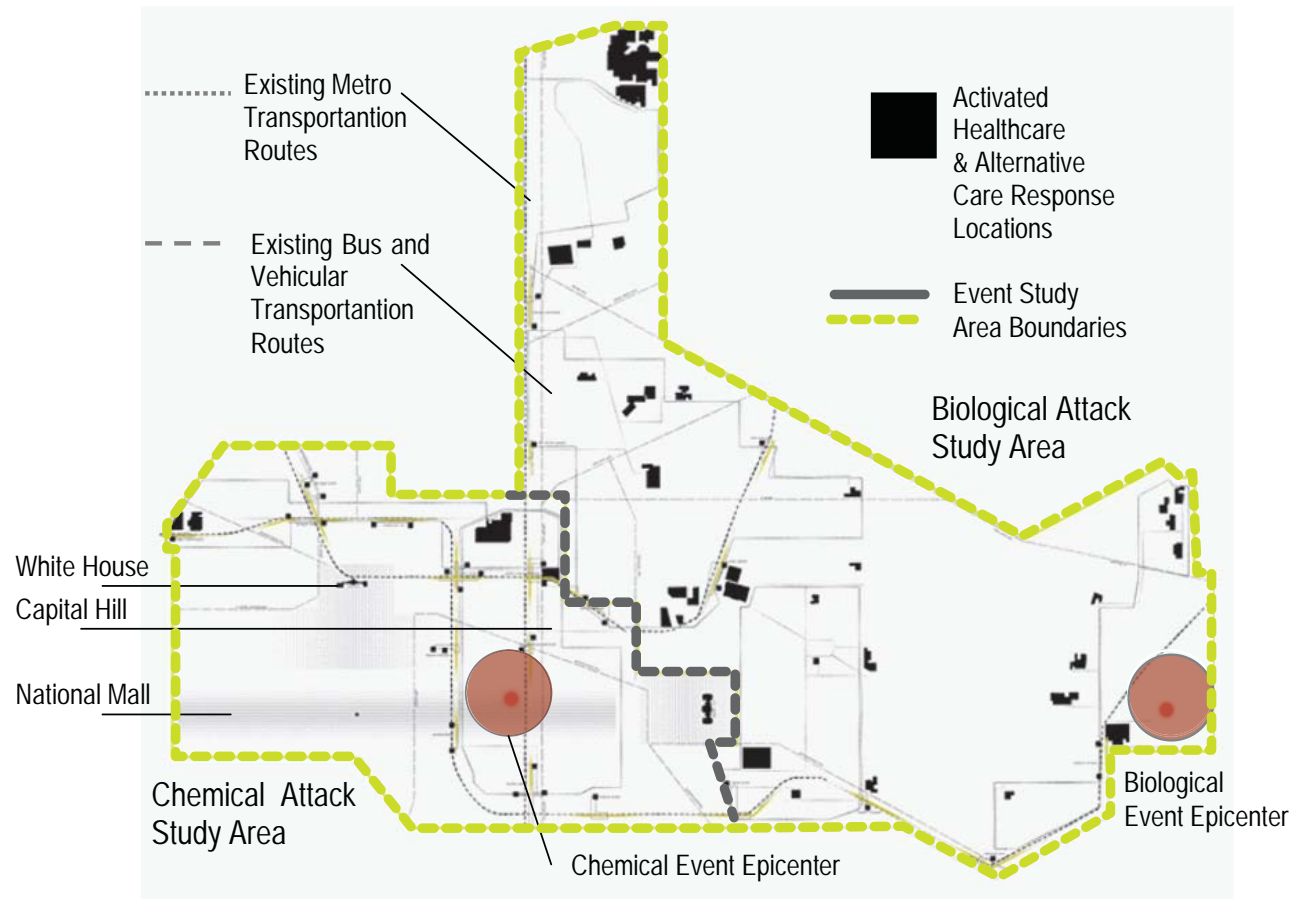


Figure 85, Concentrated Event Study Areas

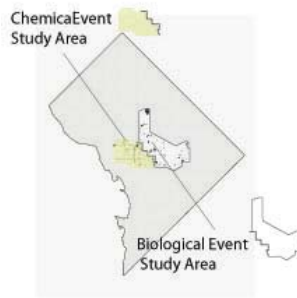


Figure 84, Concentrated Event Study Areas within the Context of Washington, D.C.

Scenario Proposals and Response

Two potential events located within the urban threat context of Washington D.C. are illustrated in an effort to demonstrate the capability of both the systemic and specific architectural features proposed in this thesis. Two of the greatest potential events include chemical and biological attacks. (Figure 84, and Figure 85) The events include: ‘a chemical attack on the National Mall’ and ‘anthrax released at RFK.’ Each event varies in the type of incident, scenario, and context therefore evaluation a range of potential variables and their impact on a response. Both types of events will involve a large number of victims, however the timelines differ. A chemical event lasts for a matter of a few days whereas a biological event lasts for weeks. The events chosen to evaluate illustrate the range of potential variables that an architectural and systemic response will have to help manage during and following an act of bioterrorism.

Each event scenario attempts to illustrate the full capability of a response during both chemical and biological attacks. The events studied are examples of worst case scenarios; therefore any response that is capable of meeting the needs of the chosen events is capable of responding to events of bioterrorism with lower impact.



Figure 86, Epicenter for Chemical Attack
Scenario: National Gallery of Art the National Mall

This thesis studied the overall metro area of Washington, D.C. however a systemic response was evaluated within a more specific study area located centrally around each event. The study area was determined by identifying an adequate number of healthcare facilities, and alternative care locations needed to handle the load of patients predicted for each event. The study area also took into consideration the distribution of the activated response elements located within and near the metro rail and emergency routes within the city. The study area serves as a model of response that can also be applied to the entire urban threat context of Washington, D.C.

Event Scenario 1, A chemical attack on the National Mall: The first event study, a chemical release on the National Mall, takes place in front of the National Gallery of Art (Figure 86) and evaluates an architectural and systemic response to the impact of a chemical event. (Figure 87) The National Mall consists of many museums and monuments that line along a wide-open space and a highly populated area with tourists, a potential target of a terrorist attack. (Figure 78, Figure 79) Located at the end of the axis of this open space is the Capitol Building, also known as Capitol Hill, a highly significant building that houses many federal government functions as well as significant

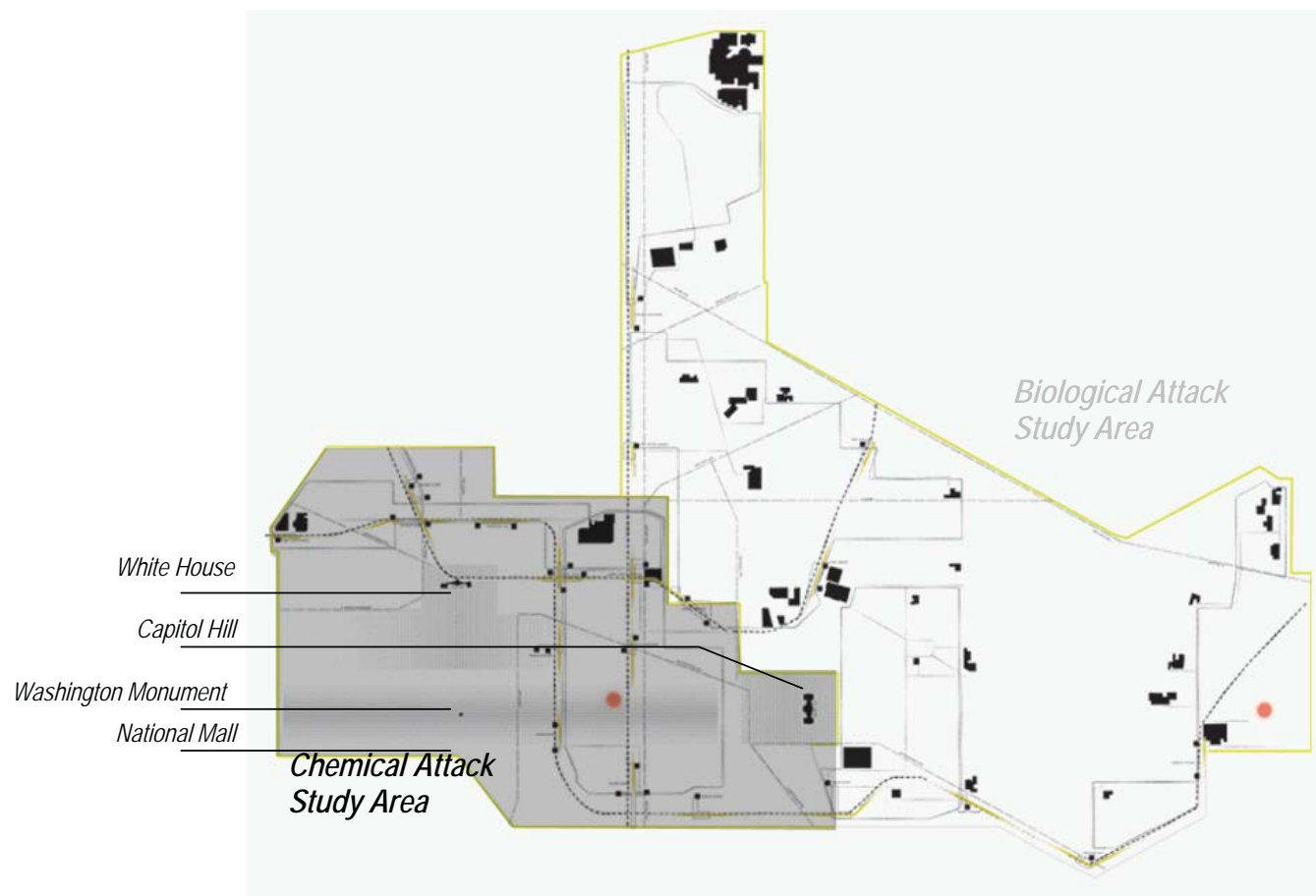


Figure 87, Concentrated Chemical Study Area and Surrounding Landmarks

representatives of the United States Legislature. The White House is also within close proximity to the National Mall. The surrounding urban infrastructure of the National Mall is a considerably high threat area based on the premise that terrorists will target densely populated, high profile areas within an urban context. A response effort that occurs on the National Mall is a unique but probable scenario based on the availability of large open spaces within an urban context.

Although this attack takes place in an outdoor setting, a relatively small number of potential victims is exposed—150 people, of which 50 are diagnosed in critical condition. The response context is primarily located at the event epicenter with the assistance of existing resources—the National Metropolitan Response Team (NMRT). This event spans a timeline of three days. The epicenter serves as the response context where NMRT responds and provides decontamination. Despite efforts made at the epicenter many potential victims move outside the containment area before it is established. Therefore activated responses including the display of public health information, and self-diagnosis to potential victims who have dispersed throughout the urban context are activated throughout the broader context of the metro system; the primary delivery of care however is decontamination at the epicenter.

A response must provide the walking well with information about the event and the agent that has been released so that they can determine whether or not they have been exposed. Systemically during this event the transit network is adapted and used to transport victims who have dispersed throughout the context so that they can return back to the epicenter where they will receive decontamination and further evaluation from medical responders. The immediate recognition and awareness of a chemical agent conveyed in this event scenario allows for an immediate response strategy.

Sequence of Events during a Chemical Attack on the National Mall: At 9:10 in the morning tourists are beginning to arrive at museums along the National Mall. Federal employees are walking and driving near the Mall to get to their offices. At a nearby metro station commuters are exiting onto the Mall. The National Mall is moderately populated with a wide variety of people—all potential targets of terrorism. An indiscrete, empty bus is parked on a street lining the Mall. (Figure 80) Without warning, a chemical bomb planted within the bus explodes spreading mustard gas throughout the immediate context. One hundred and fifty people within the epicenter



Figure 88, Empty Bus Houses the Chemical Bomb on the National Mall

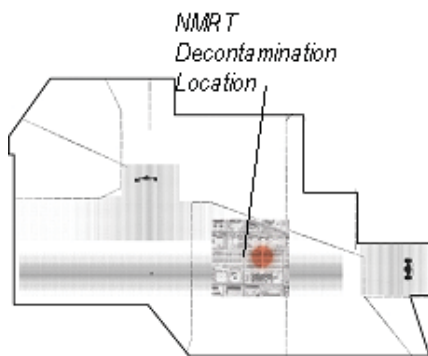


Figure 89, Chemical Attack, Epicenter, Location for NMRT to provide Decontamination

are infected; fifty of them are critically injured. The chemical agent is immediately detected by a monitoring device located within close proximity to the epicenter (on the Mall.) Emergency officials immediately confirm the chemical agent, and emergency responders within close proximity are dispatched to the epicenter. NMRT, located less than ten minutes away in Arlington, Virginia is sent to the site in order to provide mass decontamination. George Washington University Hospital in notified of the attack and immediately begins to prepare for the influx of victims.

During the end of the first day, during the timeline of the event, the majority of actual victims have been identified and treated at the decontamination site administered by NMRT. (Figure 89) In order to prevent the walking well from inundating NMRT at the epicenter, metro stations throughout DC remain activated to provide public health information. Thermal scans within close proximity to the epicenter remain activated and on average an additional one-hundred fifty potential victims are performing thermal scans per hour, although none show a positive result. Metro lines remain closed allowing exposed, non-critical victims the opportunity to utilize the response network—including thermal scans, public health information and self-diagnosis if necessary. The lines

remain closed to the public to prevent additional people from entering the epicenter and overwhelming responding healthcare facilities. The local bus system supplements the conventional metro system by providing additional buses along the same route that the metro would be operating, allowing commuters throughout the city to continue normal movement through and out of the city. During rush hour, the bus lines remain active to provide transit along the full length of metro lines, allowing commuters who normally rely on the metro rail to leave the city.

The number of non-critical victims presenting themselves for decontamination is low, and almost non-existent. At the end of the response effort, the network control center is no longer necessary to collaborate response efforts; it is deactivated. All response sites and systems that had been activated throughout the metro stations are also deactivated. NMRT begins to breakdown their equipment and discontinue services, as all infected patients have been identified and treated. Post-event, the Environmental Protection Agency begins to clean-up the epicenter as well as evaluate and clean-up the area surrounding the epicenter. Part of the clean-up process includes destroying activated

elements such as thermal scans. Understanding that the majority of critical patients will be treated at the epicenter, it is still a viable assumption that thermal scans (for example) may be exposed to a chemical agent through contaminated victims. Additionally, the proposed materials that are used to construct thermal scans may not be able to function as needed during future events after being decontaminated. Therefore they are removed, and replaced post-event. Ultimately, metro stations are reopened to riders, after sensors within the Metro and surrounding areas deem the air quality safe and non-contaminated.

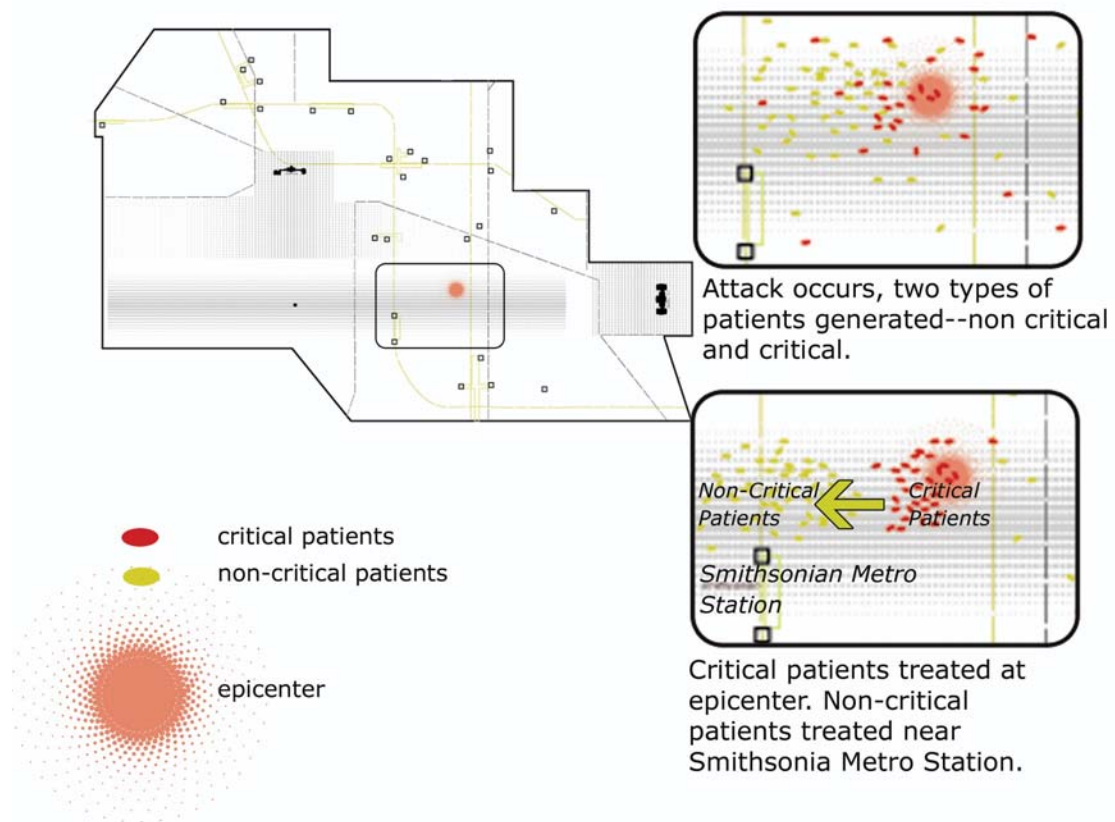
9:10 a.m.



Non-critical but exposed victims begin to disperse throughout the urban context and away from the immediate epicenter.

Emergency response arrives at the National Mall and begins to treat critical victims at the epicenter. Emergency responders transfer non-critical victims to a location downwind of the epicenter where treatment will occur.

Figure 90, Victim Dispersion



Post release of mustard gas, because of the fact that the agent is odorless, victims within proximity to the event who believe that they were far enough away from the explosion and are therefore not infected, begin to disperse throughout D.C.

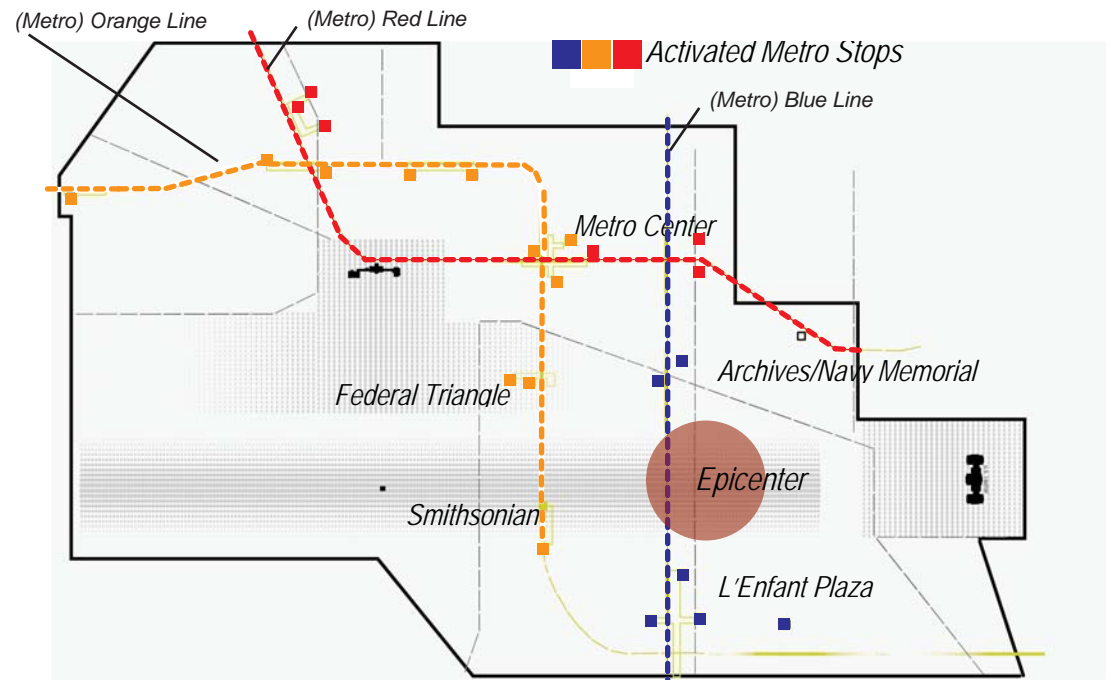
Figure 91, Victim Flow

9:15 a.m.

Communication Network activated at a hospital outside the range of impact

Metro rail lines shut down to prevent riders from exiting and dispersing throughout the urban context. Trains along the red, orange and blue lines that recently passed through the Mall area L'Enfant station plus the Smithsonian Metro Station are evacuated so that potential victims can exit at the Metro Station and perform individual thermal scans; public health information is displayed at the platform level.

Oncoming trains are stopped before reaching the Smithsonian Metro Station, as well as surrounding metro stations, preventing people from dispersing into the epicenter.



Metro Center, Smithsonian, Federal Triangle, Archives/Navy Memorial and L'Enfant Plaza—metro stations with potentially infected patients that could have dispersed activate thermochromic surfaces and self-diagnosis stations as well as public health display elements that informs potential victims of their possible exposure.

Figure 92, Activated Metro Stations

9:20 a.m.

Emergency response dispatched to assist within the metro system at stations where trains are evacuated.

Responders and metro employees within stations assist victims, and redirect the walking well; digit signage also conveys information as to how to exit the metro station.

Riders including acutely exposed victims and the walking well, waiting on the platform at stations within proximity to the Mall are evacuated from the metro station; after all metro trains have been evacuated rail lines are closed and are dedicated only to be used for emergency response transportation.

Potentially infected riders waiting on the platform self-test themselves (to confirm exposure) by interacting with thermal scans to determine whether or not infected.

The ticketing system is converted to allow patients who received a positive diagnosis from the thermal scans to perform a further, more in depth self-diagnosis.



Thermal scans are activated at the platform level to provide an instant diagnosis for potentially infected victims forced to evacuate trains that would have been in proximity to the National Mall during the attack.

Figure 93, Activated Thermal Scans

9:25 a.m.

NMRT arrives at the epicenter to set up a mass decontamination unit.

9:30 a.m.

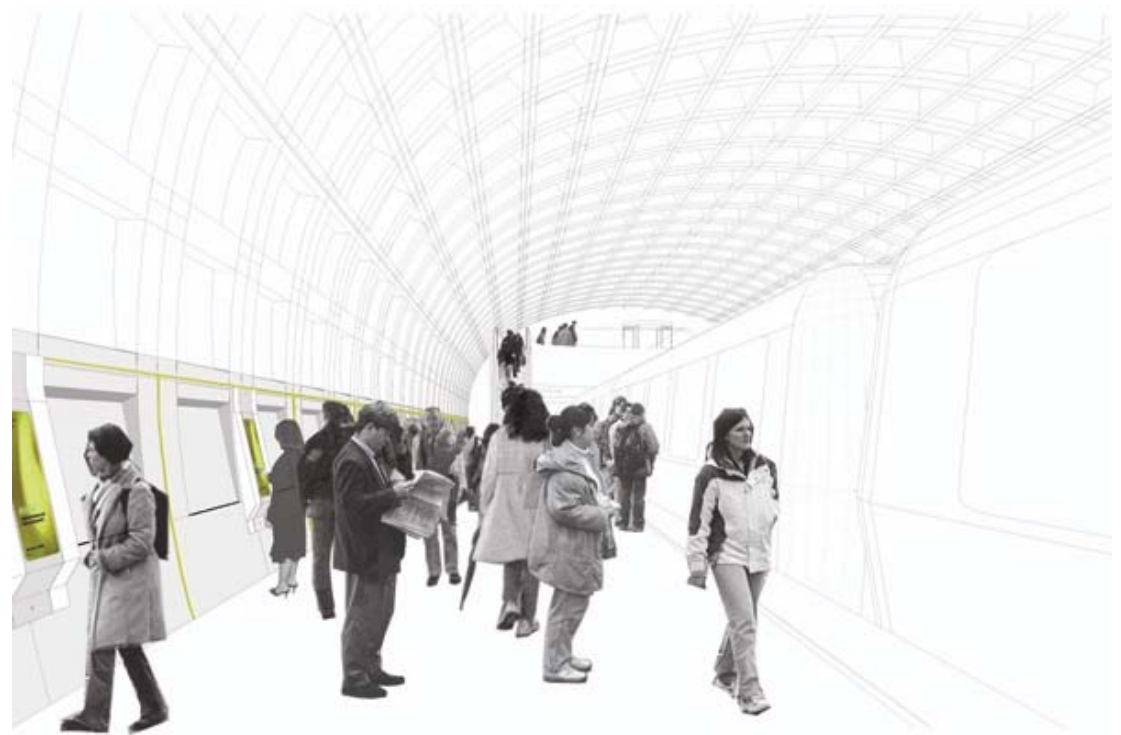
Critical victims from the epicenter transferred to George Washington University Hospital

9:35 a.m.

Media coverage begins in collaboration with the Communication Network begins.

Throughout the city announcements and alerts are sent to advise the public of the situation.

The communication network relays information to the public, in particular where the walking well and non-critical victims can receive care.



Displays at metro stations within close proximity to the epicenter as well as those dispersed throughout the city are activated to inform the public that an attack has taken place and necessary precautions should be taken by the public domain as a whole.

Figure 94, Activated Public Health Information

9:45 a.m.

Non-critical victims begin decontamination administered by NMRT at the epicenter.

Evacuated victims at metro stations receive further diagnosis of exposure if thermal scan indicated exposure to agent.

Non-contaminated commuters, those who received negative results from the thermal scan are evacuated from station.



Thermal scans are activated at street level providing diagnosis for potential victims throughout the city.

Figure 95, Activated Thermal Scans at Street Level

10:00 a.m.

Victims in need of further care and decontamination transported to decontamination site near epicenter via the orange line of the Metro rail.

10:05 a.m.

Entry to the metro reopened, although the red and blue lines remain closed to provide transportation to alternative care locations.

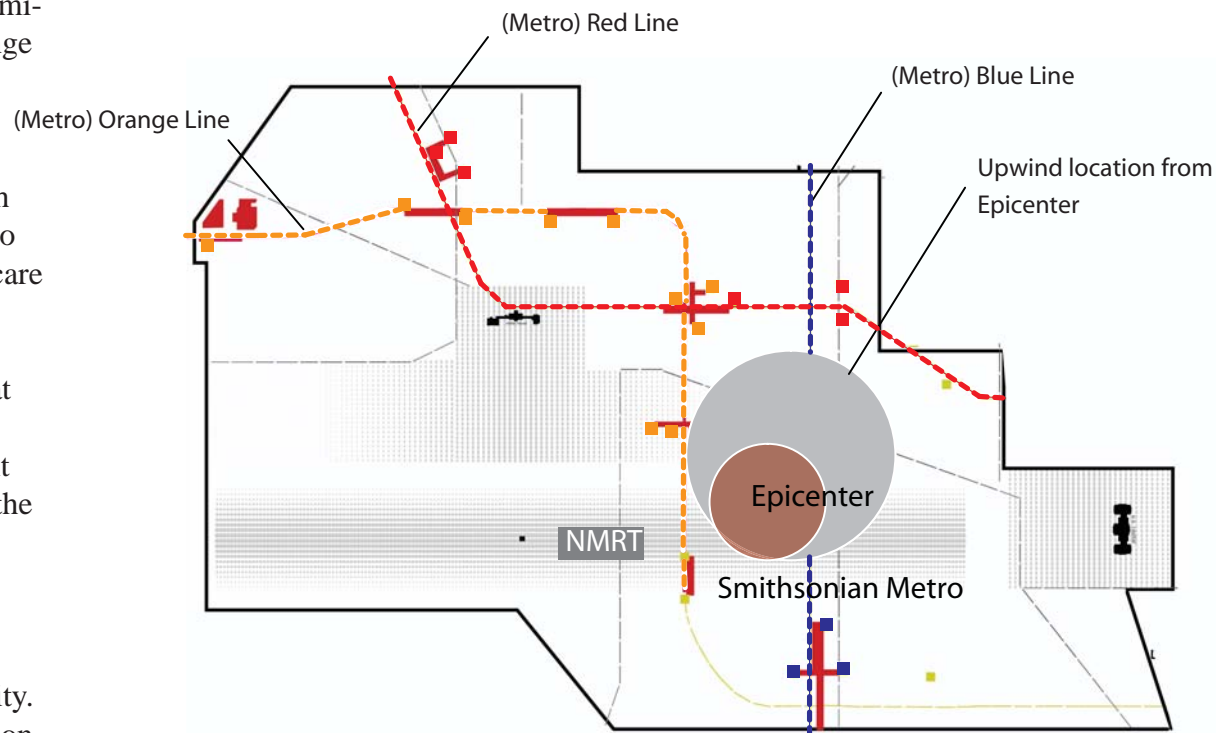
Public health information displayed at Smithsonian Metro entrance.

Large amount of walking well present themselves due to their proximity to the epicenter.

10:30 a.m.

At epicenter all critical victims have been transported to a healthcare facility. Treatment at the epicenter is focused on the walking well and non-critical victims.

Hazmat teams, as well as the Environmental Protection Agency (EPA) evaluate the extent of the release and the intensity of the clean-up.



At the epicenter, decontamination is set up to provide care to non-critical, infected victims. Victims are transferred from self-diagnosis sites located within the metro station via the metro line to the context in which care is being delivered by NMRT.

Figure 96, Infected Patients Transported

10:35 a.m.

Hazmat teams, as well as the Environmental Protection Agency (EPA) evaluate the extent of the release and the intensity of the clean-up.

Areas upwind of epicenter are evaluated to further understand the breadth of area the agent traveled. (Figure 97)

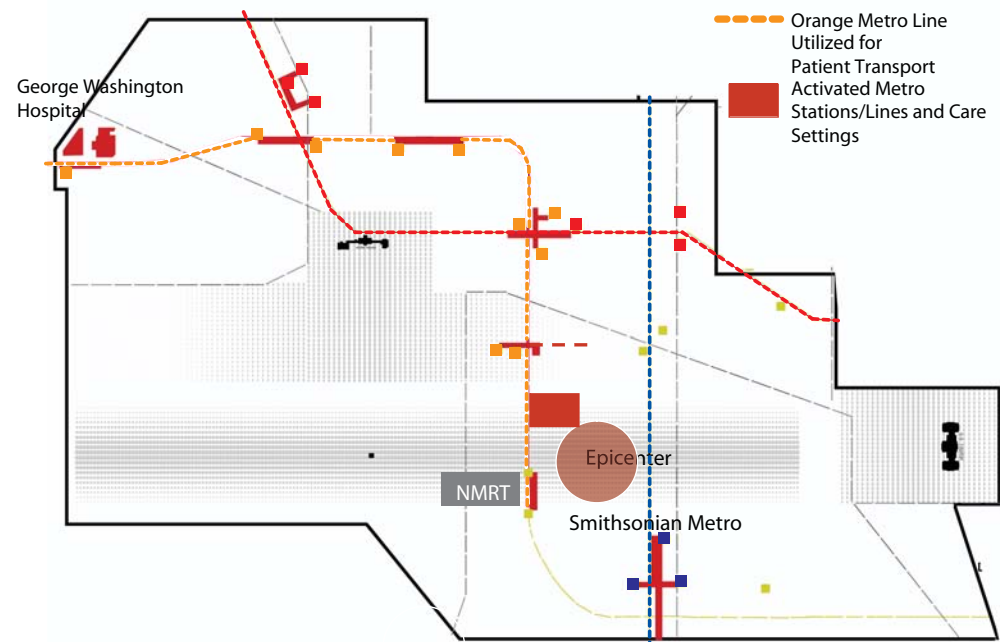
Majority of known victims have been decontaminated.

Law enforcement assists the NMRT in crowd control.

11:00 a.m.

Remaining Metro Stations activated throughout the city.

150+/- riders/pedestrians are receiving thermal scans an hour.



1-2 new victims are diagnosed and transported to the Smithsonian Metro Station where they are transported to George Washington Hospital. The number of infected victims remains constant throughout the city over a 24 hour period. The majority of victims however do not return a positive thermal scan.

Figure 97, Infected Patients Diagnosed

11:00 a.m. (Cont'd)

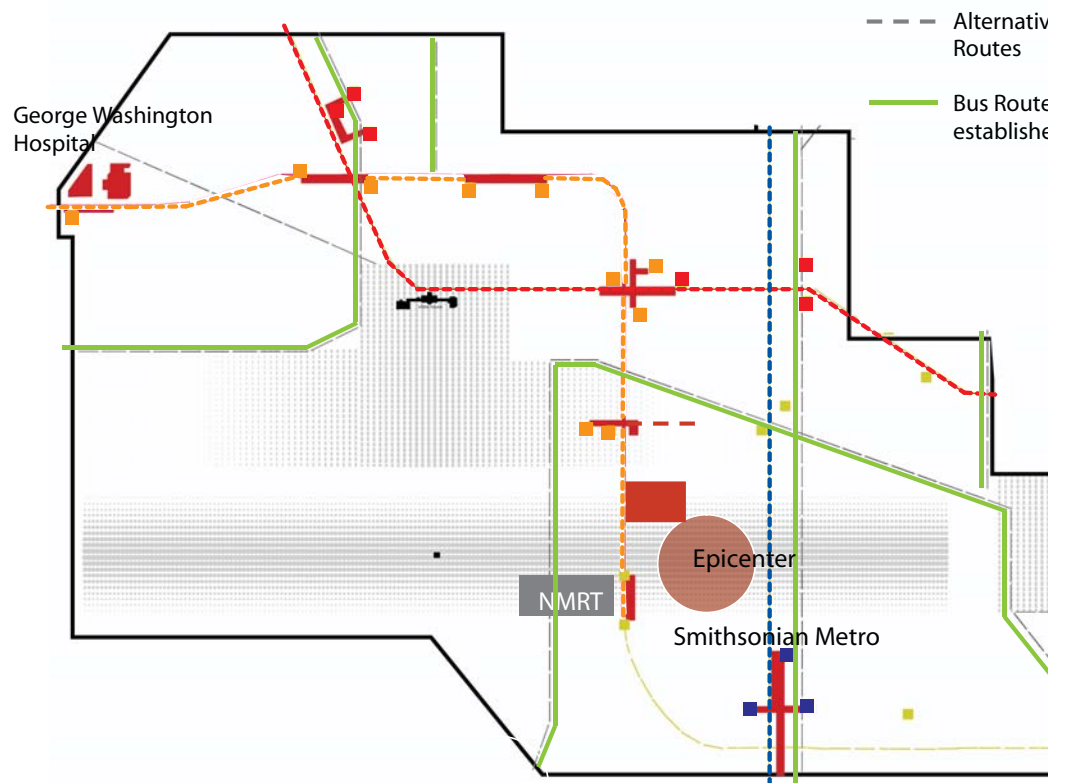
Emergency vehicular routes throughout the city are not inundated with exiting employees/residents.

The communication network and media continue to provide coverage and alerts.

The major form of communication is through the communication network (located in MD).

Non-critical patients have been decontaminated by NMRT.

Walking well - required to proceed through thermal scans, before decontamination is administered; few patients need decontamination.



Metro lines remain closed; traditional riders forced to use other transportation systems supplemented by the metro bus system that creates new (temporary) lines along traditional metro routes.

Figure 98, Alternative Transportation

12:00 p.m.

Thermal scan use at the entry level increases as the number of people/employees increases during the lunch hour.

Public health information intensifies.

No victims needing decontamination are detected within the system.

2:00 p.m.

Communication network staff and EPA decide to re-open Metro lines.

Pneumatic barriers located at entry gates are removed, destroyed and replaced by trained metro engineers.

Entry to the Metro stations is reopened.



Figure 99, Pneumatic Barriers activated at Street Level

3:00 p.m.

The majority of self-triage units converted back to latent function of ticketing.

Few remain open as self-diagnosis and public health information.

Thermal scans still deployed at entry level.

4:00 p.m.

Due to the impact on the Metro system, metro buses continue to run along the Metro line routes so that normal metro riders are transported out of city during rush hour.

NMRT remains deployed on the mall throughout the night – several remaining infected patients receive decontamination



Figure 100, Self Diagnosis Activated



Figure 101, Metro Stations Reopened

Day 2

9:00 a.m.

EPA begins initial clean-up of the epicenter, as well as local metro station.

The number of people continuing to present as infected is low, and almost non-existent.

1:00 p.m.

Communication center officials and the EPA decide that thermal scans can be deactivated.

Thermal scans within the outer limits of the district are removed, destroyed, and replaced by trained metro engineers.

6:00 p.m.

Remaining thermal scans within close proximity to the epicenter are removed, destroyed, and replaced by trained metro engineers.

Day 3

9:00 a.m.

NMRT breaks down decontamination site.

Epicenter clean up begins.

Public health officials continues to provide information about the clean-up of the agent.

Clean-up and monitoring of the epicenter as well as localized Metro stations begins and continues for several days.

Riders are permitted within the Metro system; sensors within Metro deem air quality safe.

Trains used for transportation during event are studied and evaluated for possible contamination.

Architectural Conclusion, A Chemical Attack on the National Mall: This chemical event scenario demonstrates the ability of an architectural and systemic response to activate immediately and serve a high number of potential victims within a concentrated area and brief amount of time. During a chemical attack it is significant to consider existing resources that may be able to handle the load of a mass decontamination facility. In this instance, a mobile response team, the NMRT, was capable of providing this program response. Part of the success in enabling their response is the fact that they, unlike many mobile response models are able to be self sustaining without having to ‘plug into’ external resources. NMRT provides their own water and electrical resources. The ability to set up and provide care regardless of sources such as water, and electricity make NMRT a more flexible form of mobile response; however it can be assumed that most typologies of mobile response will need to be able to utilize existing sources of water and electricity. The location of this event enables the metro to play a significant role during the response, in particular dealing with the task of informing the public. It is reasonable to believe that the proposed systematic and architectural interventions were capable of responding to the immediate needs of a response during a mid-size chemical attack located within a densely populated, potential urban threat context.

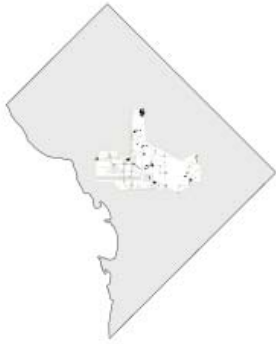


Figure 102, Concentrated Biological Event Study Area within context of Washington D.C.

Event Scenario 2, Anthrax released at RFK: Event two, anthrax released at RFK, is not only located within the stadium, but also the residential context that surrounds it. (Figure 102, Figure 103) During the event populated by 50,000 attendees, a truck driving upwind of the stadium releases anthrax into the air infecting 10,000 fans and 3,000 residents. Post event, fans disperse throughout the metropolitan area unnoticed. Several days after the initial release, patients begin to show up at local emergency departments with symptoms similar to the flu. Five days after the initial release anthrax poisoning is recognized (in part due to the increasing number of patients with similar symptoms.) This event spans for twelve days, a much longer period of time than the chemical event studied. The primary architectural response during this event is self-diagnosis. The primary treatment needed is immunization located at multiple sites within the alternative care network. This event involves prolonged times and the potentially high number of victims (including the walking well) who will need diagnosis and treatment. A response must be capable of responding immediately, but it must also be capable of prolonging its activated function for a longer period of time.

During the remaining duration of response, the network control center, particularly the media component, continues to provide widespread coverage throughout the metropolitan area. Public health information continues to be updated at activated public health terminals throughout the metro system. Residents within close proximity to the stadium in particular are advised to seek further care, and are administered antibiotics. Additional alternative care locations, such as the DC Armory adjacent to RFK, is activated. The Armory is located within proximity to the metro transit system providing access for potential victims. This facility would be activated as an alternative care locating providing minor care and (potential) vaccination to non-critical victims. The large size of this facility would be capable of compensating for the influx of patients within the metro area, including Maryland and Virginia (as well as the District of Columbia).

As the awareness of the event increases, the number of activated thermal scans and self-diagnosis terminals amplifies within the metro system to provide care for the walking well. Despite the increase in non-critical patients seeking care at alternative care locations, antibiotics are still available and continue to be distributed throughout the city.

By the end of the seventh day of the response, patient flow decreases, and alternative care locations begin to deactivate. Additionally thermal scans and self-diagnosis terminals no longer in demand by the walking well are deactivated so that their latent function can be restored. Post-event decontamination of the self-triage kiosks and thermal scans must occur due to the large number of patient typologies that have come in contact with the proposed architectural interventions. Additionally it can be assumed that during the post-event timeline the reinstallation of architectural interjections utilized during the response would occur so that the threat context is prepared for future response efforts. For example self-diagnosis terminals would be decontaminated, and converted (internally) to their latent function of ticketing. Thermal scans would be deactivated and reinstalled to their latent position in preparation for a future response effort. Only a few larger alternative care locations, such as the DC Armory, Convention Center and Verizon Center Arena remain active. (Figure 111) Both facilities are larger and capable of handling the remaining victim load. Throughout the metro system, cleanup administered by the Environmental Protection Agency (EPA) occurs; this is the same process that would occur after a chemical event. This would involve the process of cleaning and decontaminating response locations to ensure that the agent has been

eradicated and is no longer a threat to the public. It is important to perform a clean-up process so that the public is ensured of their safety. Post clean-up metro stations would return to their daily, latent capabilities. The overall cleanup and decontamination of the metro system and alternative care locations lasts for five days, making the total duration of response to a biological agent twelve days.



Figure 104, Box Truck

An event at RFK stadium becomes infected as a truck driving upwind of the stadium releases aerosolized anthrax into the environment.

10,000 fans and 3,000 residents are exposed to the agent.

10:30

Post game, fans disperse throughout the metropolitan area, including Washington, D.C., Virginia, and Maryland.

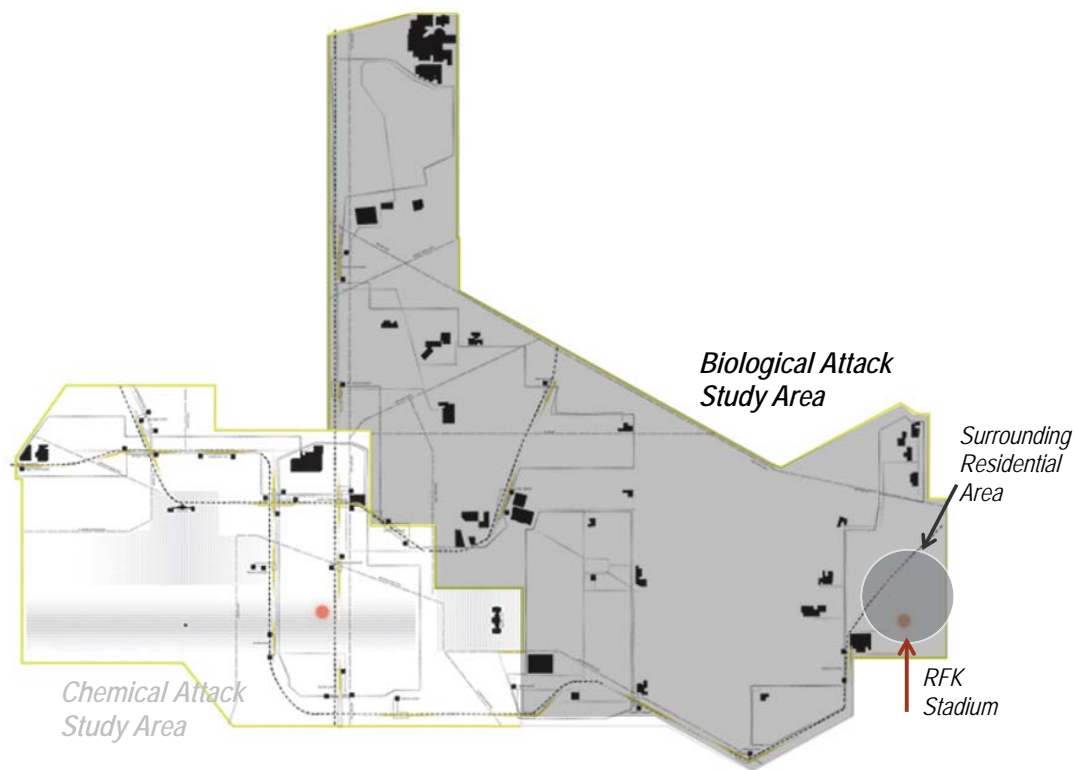


Figure 103, Concentrated biological event study area

Day 2

Biological agent unconfirmed.

People exposed at the game, or within proximity to RFK during the time of release move about the region without knowing that they have been exposed.

public health information.
Thermal scans still deployed at entry level.

4:00 p.m.

Due to the impact on the Metro system, metro buses continue to run along the Metro line routes so that normal metro riders are transported out of city during rush hour.

NMRT remains deployed on the mall throughout the night – several remaining infected patients receive decontamination.

Day 3, Morning

3,000 patients become symptomatic;
1,200 with flu like symptoms go to local hospitals.



Figure 105, Biological Attack Epicenter and Surrounding Metro Area

Day 3 (cont'd)

Increase in patient flow considered a possible increase in influenza exposure; anthrax not considered. 59 people die as a result of exposure to anthrax.

Evening

Anthrax confirmed and linked to the deaths that took place throughout the day.

6:00 p.m.

The communication command center—established outside of the urban threat context in Maryland, conveys public health information such as signs of exposure, self-triage locations and activated alternative care locations, throughout the metro system, and through media resources. Care locations are activated.

Thermal scans activated at Metro station entry points. Ticketing systems converted to provide further self diagnosis. Healthcare facilities are activated and begin treating critical patients; Alternative care locations begin to serve non-critical patients.

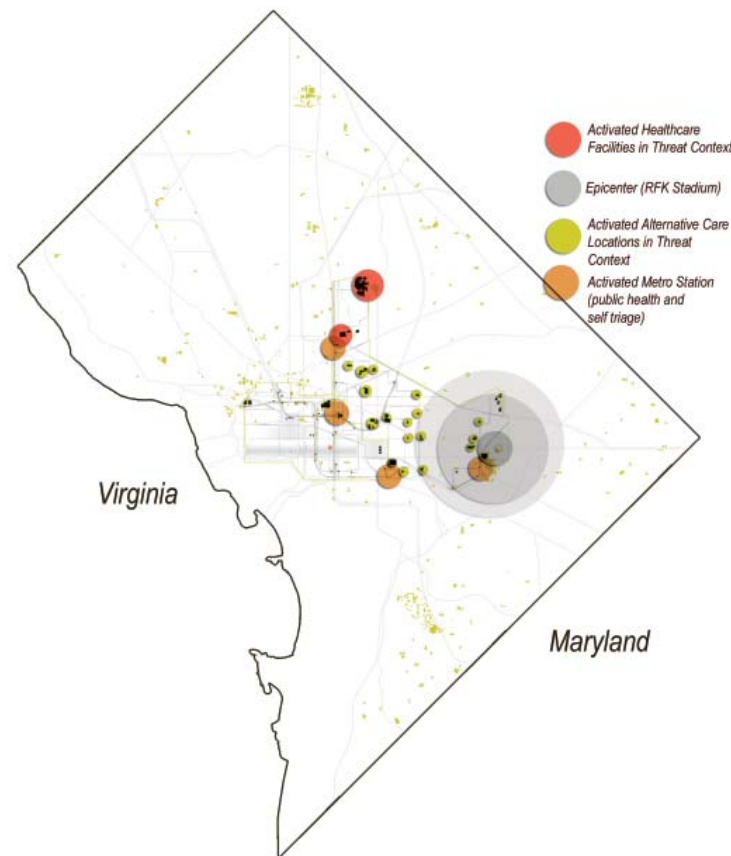


Figure 106, Activated Care Locations

7:00 p.m.

The Environmental Protection Agency (EPA) and HAZMAT teams investigate the exposure and remains of agent at the epicenter (RFK stadium). Event attendance studied by healthcare officials represented within the communication network to evaluate spread of disease.

The Centers for Disease Control [CDC] contacted; vaccines processed and released to Washington D.C. area hospitals and alternative care locations.

8:00 p.m.

The proposed alternate care network, such as schools, and larger convention centers and arenas, within Washington DC are staffed and begin to set up, in anticipation for the predicted patient flow beginning the next day.

Day 4

Morning

Alternate locations primarily schools within the immediate threat context are activated for immunization of non-critical patients.

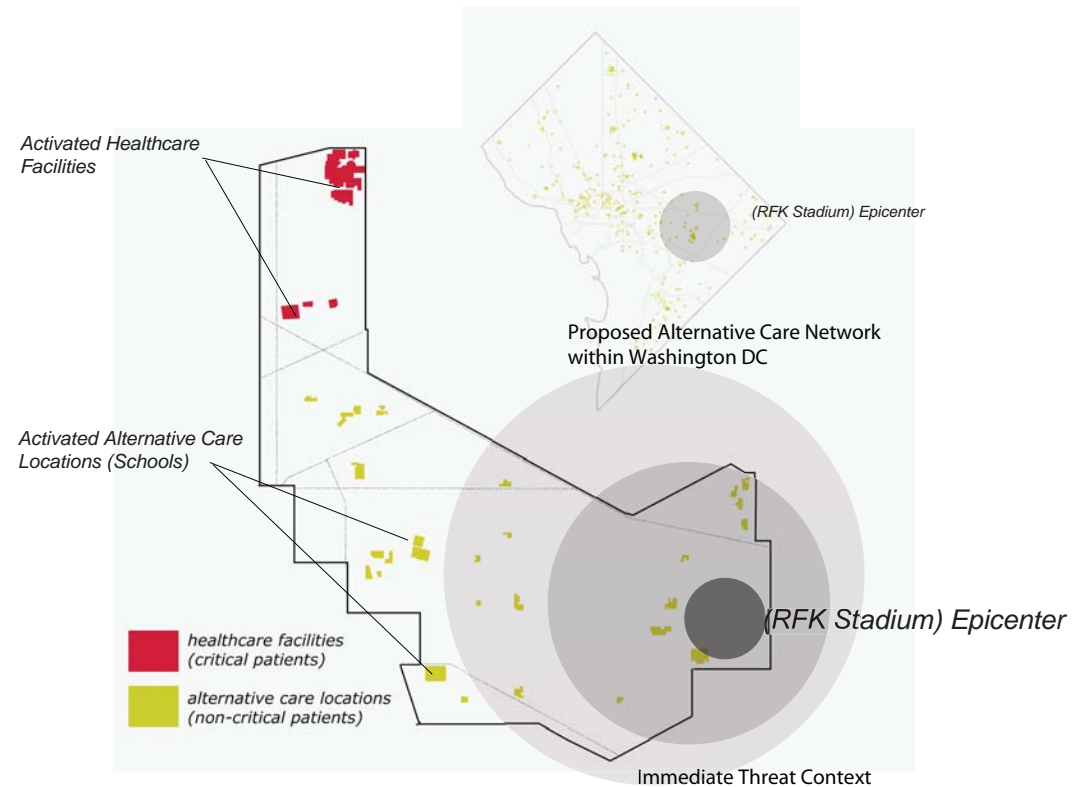


Figure 107, Biological Event Epicenter

5:00 p.m.

The network of alternative care locations throughout the urban context remain the primary points of care served by public health officials, and clinical staff. However, medical staff remains primarily at activated hospitals to provide care for critical patients.

Metro trains run on limited tracks (Red and Orange Lines) that have been converted to provide transportation of infected patients to healthcare facilities, and well as less critical patients to alternative care locations.

Bus Routes are converted to transport patients to healthcare facilities from activated metro stations (on the orange and red line).

Wayfinding routes-both vehicular and walking are activated from metro stations to the activated alternative care locations.

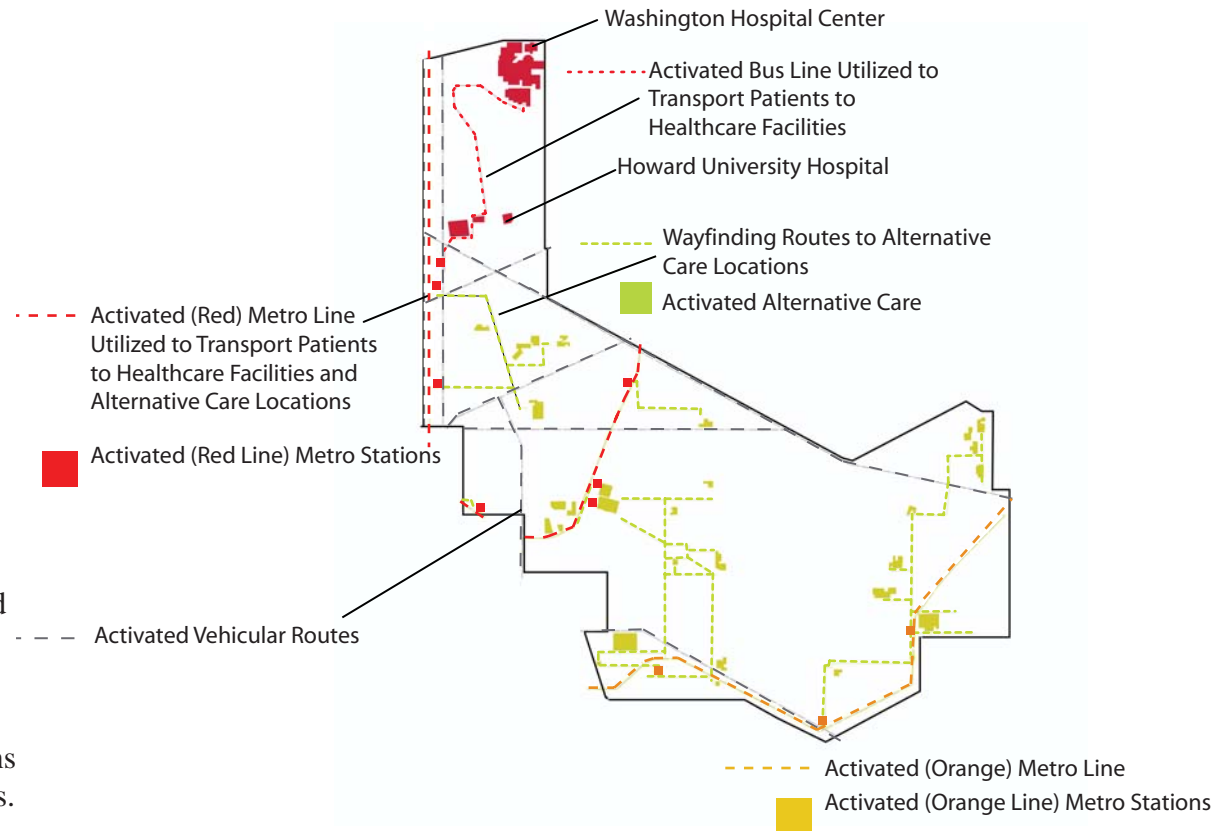


Figure 108, Alternative Transportation

Day 5-6 Continues

Morning

Metro trains run on limited tracks, as some metro rail lines are converted to provide transportation of infected patients to healthcare facilities (Washington Hospital Center and Howard University Hospital), and well as less critical patients to alternative care locations.

Thermal Scans are activated at Metro Stations

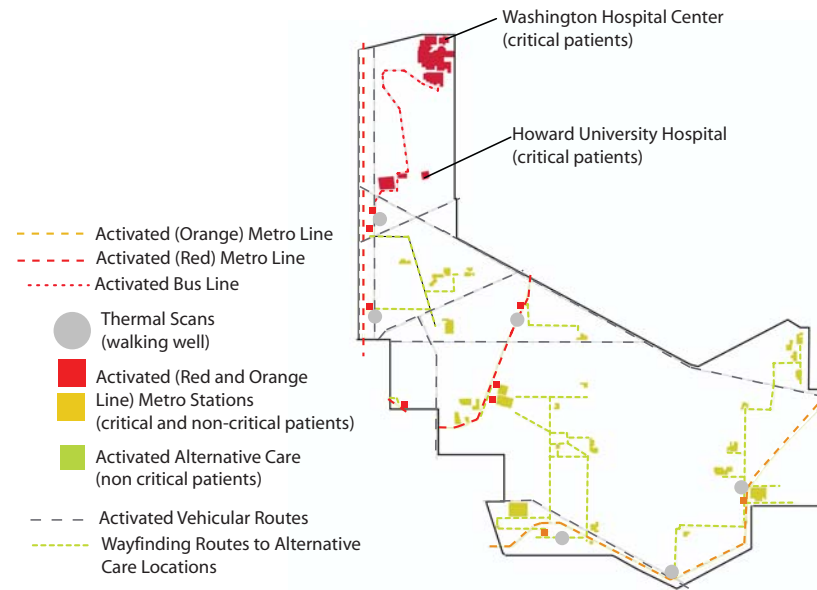


Figure 109, Adapted Metro Lines

Day 5-6 Continues

Morning Cont'd

1,300 Patients confirmed ill, treated at hospitals throughout urban context.

2,000 walking well utilize thermal scans (Figure 98) throughout the morning rush hour at metro stations. 1,500 produce negative results and progress to self-diagnosis stations to further assess their state of health. The majority of these patients are confirmed to need further treatment or immunization and present themselves at alternate care locations.

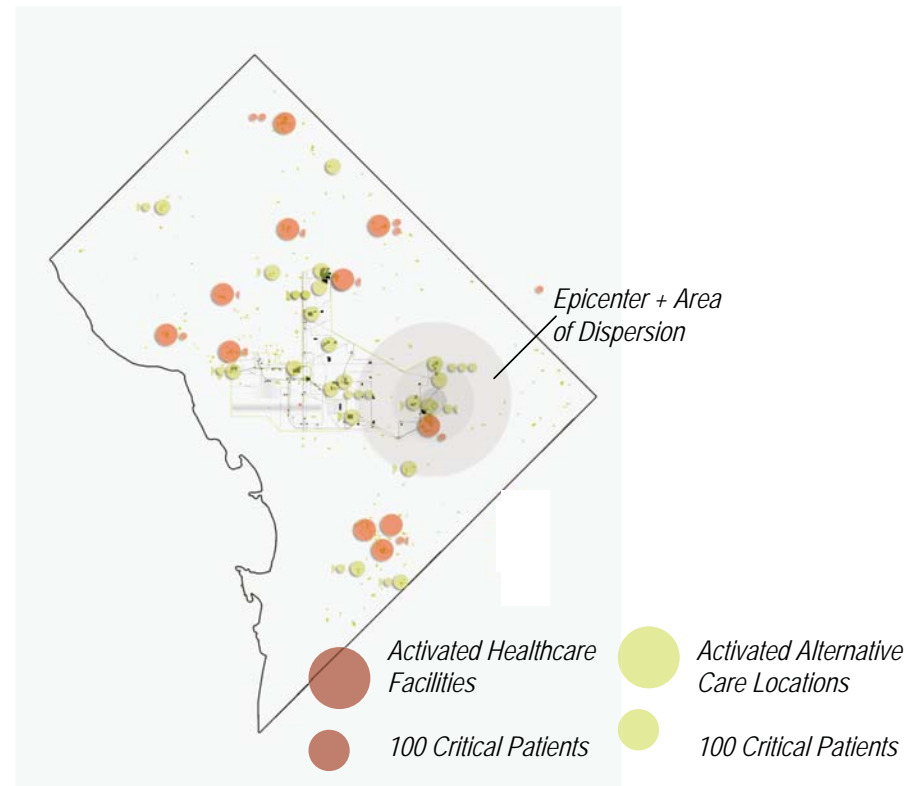


Figure 110, Patient Population & Dispersion

Architectural Conclusion: Anthrax Released at RFK:

This biological event scenario demonstrates the scope and nature of a response on a widely dispersed level throughout the entire urban context and how it might serve a potentially high number of walking well over a prolonged amount of time. During a biological attack it is significant to consider existing resources and alternative care locations that would be able to handle the load of the walking well and non-critical patients.

The length of time between the release of a biological agent and recognition can be a matter of days, unlike the immediate awareness of a chemical response. Between the initial release and recognition, victims have dispersed and cannot be as easily contained and treated. Providing public health information, and opportunities for self diagnosis, including thermal scans and self-diagnosis terminals at a dispersed level throughout an urban context provides the opportunity for potential victims and the walking well who have dispersed from the initial epicenter to determine whether or not they have been exposed. Healthcare facilities are able to handle the load of victims who are critically ill because their numbers are significantly less than non-critical patients. A greater number of walking well will inherently be generated because of the delay in recognition, and therefore a response will rely heavily on establishing alternative care

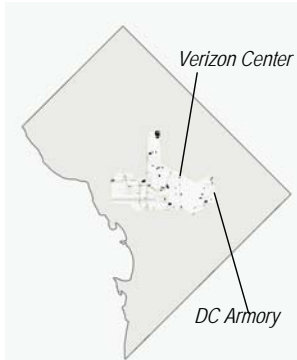


Figure 111, Remaining Active Care Locations

locations for this patient typology.

Architectural Conclusion for Overall Scenario Proposals and Response: Two potential events located within the urban threat context of Washington D.C. were illustrated in an effort to demonstrate the capability of both the systemic and specific architectural features proposed in this thesis. Although each event varied in the type of incident, scenario, and context the intent of this evaluation was to study a differing potential variables and their impact on a response. Each type of event involved a respectively significant number of victims; however the timelines differed greatly—from an immediate, short response to a delayed, prolonged response.

Each event scenario illustrates the potential capability of a response during both chemical and biological attacks. The events studied were examples of typical event scenarios; therefore any response capable of meeting the needs of these hypothetical events could reasonably be expected to respond to potentially less significant events of bioterrorism.

This thesis studied the ability to utilize existing resources throughout the area of Washington, D.C. including the metro transit system and existing infrastructure. Given that an act of bioterrorism is a low probability, high consequence event, a response must utilize existing multi-purpose resources in order to be cost effective and efficient. Similarly, a response must be dispersed to meet the unpredictable demands and location of an event epicenter within potential urban threat contexts. These events demonstrated that responses must be flexible to meet the demands of patient flow during an event. Existing healthcare facilities have the ability to handle the predicted number of critical victims in particular since these victims will be in the minority during a response effort. The most significant need identified throughout this exercise is the ability to serve the walking well at a distributed level throughout a context so that they are directed appropriately away from traditional healthcare facilities.

Further studies regarding an act of bioterrorism may explore the ability of a response effort to react to multiple events within a single urban context. If more than one event were to occur at once, how would a response effort react, and would there be sufficient resources to handle this type of threat? Another event study may examine the possibility

of an urban threat context being evacuated. This type of event would examine the capability of the proposed architectural interjections to respond appropriately—if potential patients are forced to evacuate the threat context, how do dispersed elements, such as thermal scans, and self-diagnosis terminals provide an appropriate response? It can be assumed however that this type of event would demonstrate the need for a response to occur at a distributed level outside of the defined urban threat context.

This thesis has focused on a significant, and traditionally unaddressed population that has the ability to present themselves in great numbers—the walking well. This population has the ability to cripple existing healthcare facilities that would otherwise be capable of handling most event scenarios. Any response to an act of bioterrorism must be able to address this population at a highly dispersed level throughout a threat context.

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