LIFE SAFETY AS A DESIGN DRIVER:

DESIGNING AN EMBASSY FOR THE 21ST CENTURY

OF HAWAI'I AT MANOA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

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By

Christopher R. Gaydosh

Thesis Committee:

Lance Walters, Chairperson

James Dator

Kevin Miyamura

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Abstract

Life safety has been and will always be a design driver in all forms of architecture. This thesis looks at evolving life safety design concerns, their impact on architecture, and how to better anticipate future safety concerns. It focusses on events in the 20th Century which have developed as the result of a cyclical process which starts with the knowledge or presence of harms that bring concern for improved safety. The concern for life safety issues stems from a tragic event, the development of new technologies, and societal changes. Adhering to current life safety codes as well as applying a preferred futures design approach allows for innovative designs and ideas to be considered to improve life safety standards. Life safety drivers in the built environment considered in this thesis include access to the site and structure, building materials, occupational health, support technologies, and governance. Focusing on these drivers can allow the building design to be more responsive towards current threats as well as new threats that may arise in the future. One of the newest, most impactful life safety design challenges of the 21st Century is blast mitigation. The importance of blast mitigation in design is especially evident in public architecture and government facilities, including embassies. The preferred future design approach described in this thesis provides a tool for the designers to use to better anticipate possible changes in life safety in design.

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Chapter 1: Introduction

Life safety issues have fused with the built environment since its inception. In architecture, life safety responsibilities began with the decree of Hammurabi's Code.[1] During his reign, King Hammurabi made it law that the architect is to assume responsibility for any harm to a person from a building failure. The decree was the earliest form of life safety. Today, there are numerous building components and design considerations that address improving life safety from a wide and expanding range of potential harms.

Fire protection is the primary focus for contemporary life safety development and covers an array of potential dangers to humans that may result in a fire. The first notable life safety organization was the National Fire Protection Association (NFPA). Early NFPA studies focused on the principal causes of loss of life from fires. These investigations and studies evolved from major tragic incidents during the 20th century. The NFPA's findings and conclusions incorporated standards and codes that are now mandatory in building construction.

Today, life safety measures cover more than fire protection. In certain circumstances and building types, blast mitigation measures have become a factor in the design process. The location of the building and its function are strong considerations in determining the necessary level of safety precautions. Buildings that use hazardous or explosive materials are subject to specific blast mitigation measures. Building aesthetic can set the building aside from its surrounding context which can set it apart as a target or threat in some areas. This is evident in federal buildings such as embassies where blast conciderations are taken into concidereation in the design process.

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[1] Matthys Levy and Mario Salvadori, *How Structures Fail: Why Buildings Fall Down.* New York: W.W. Norton & Company. 1992.

Life safety standards are constantly changing over time. The change is due to multiple factors that are both environmental and human-made. Buildings such as embassies utilize the highest levels of life safety and security in the design process. Over time, older building may need renovations or construction of a new facility may be needed to satisfy current and future safety concerns. The renovation and construction changes can be a lengthy and expensive process.

One method of anticipating future life safety concerns is using a foresight approach in creating a preferred futures by developing and testing alternative scenarios. Futurists James Dator and Sohail Inayatullah use a method of shaping a future narrative that when used as a model for design potentially anticipates future safety concerns.

Current research seeks to understand the significant influences of life safety in design, specifically those that are inherent human drivers. First, there is an understanding of the importance and value of life safety through the analysis of previous incidents that have changed the way we design built environment. Second, there is an explanation of a futures studies approach to forming a preferred future set of circumstances and conditions. The preferred future will provide the end goal or narrative surrounding the topic's parameters, while defining the drivers and detractors the future scenario. This thesis project uses an embassy building typology to focus on necessary life safety and security design measures that anticipate emerging safety concerns by producing a preferred future scenario for embassy buildings.

Chapter 2: The Drivers of Life Safety in the 20th Century

Design for life safety is influenced by many drivers that evolve and change over time. These drivers are grouped into two general classifications, environmental forces and human influences. Over the past century, these principle drivers have required the design and construction of buildings to evolve and emerge in response to more contemporary issues and complexities.

This thesis focuses its attention on human-influenced hazards. A hazard, as defined by Andrzej Nowak in *Making Buildings Safer for People*, 'the possibility of an event that could result in the death or injury of persons in the building, or in damage to property in the building, or in the damage to the building itself.'[2] There are two ways of dealing with these hazards in buildings; through highly trained occupants on alert for particular types of hazards or through constructing buildings without hazards. Both are highly unachievable but, as a designer, it is important to analyze and test if a hazard can be elimiated or controlled through a combination of active and/or passive design strategies.

2.1.1 Environmental Drivers

Environmental drivers strongly rely on the geography and location of the building. Different geographies often require specific structural necessities or specific material performance requirements. Seasonal changes can bring harsh climatic conditions on a yearly basis that can result in damage to the built environment and harm to human life. Evidence is shown in the seasonal floods in Thailand, through the hurricane season in the Gulf of Mexico, or with the dry season across the western United States that results in frequent wildfires. These seasonal variables and environmental

[2] Andrzej Nowak, *Making Buildings Safer for People : During Hurricanes, Earthquakes, and Fires.* (New York: Van Nostrand Reinhold, 1990), 02.

differences require specific types of architectural and construction considerations and building methods.

Natural disasters are also a test by Mother Nature to push the limits of building design and life safety. Threats from tornados, earthquakes, hurricanes, tsunamis, blizzards, and other extreme weather phenomena pose unique design problems. Various methods, materials, and technologies are used to mitigate potential harms to the building, its structure and persons inside. Robust and flexible structural support is needed for earthquake-prone areas. Elevated buildings and proper drainage maintenance help mitigate dangers in flood-prone areas. Reinforced concrete over shorter roof spans reduce storm damages and improve life safety in tornado-prone areas.

Natural conditions change over time; storms often appear stronger and more intense and leave in their wake greater damage and effects on nature and the built environment. Climatic changes and their evolving impacts are continuously being studied to improve safe and livable conditions. Investigations and studies on natural weather phenomena and their results produce new information that allows for new technologies and materials to be implemented into building designs and construction.

2.1.2 Human Influenced Drivers

A majority of the drivers that influence life safety relate to various aspects of how we live today. From our ease of access to modern technologies and various options for means of transportation to our different cultures and life styles, life safety standards are a product of analyzing the needs behind these drivers. The specific safety requirements for society directly relate to how that society functions. Technological advancements and the spread of Globalization have advanced safety standards, yet different, inconsistent standards exist throughout the world.

Digital technologies have brought vast improvements to life safety in building designs in the past century. Sensors that can detect poisonous gases, fires, or intruders have resulted in significant influences on many existing building typologies. Smoke alarms and sprinkler systems have helped to improve fire safety while security cameras and sensors heightened security. Building technologies have advanced greatly as well. Early technologies such as automatic fire sprinklers and smoke detectors focused the life safety of the occupants. Now technologies also include monitoring and managing building performance criteria as well as standard life safety design.

The way we travel get around has changed and evolved over the last hundred years. The development of the automobile changed the way we plan our cities and designed our buildings. Urban sprawl in the mid-1900's created places that were further apart and that were only made accessible by the automobile. The growing need, accessibility, and reliance upon a car today has only increased the demand that we design for the vehicle. The automobile also brought new building typologies such as the car park and gas station and building space to house vehicle such as the garage. As the technology of the automobile developed, the average size of the car increased and trucks emerged. Now we have massive eighteen wheeled and flatbed trucks that require loading docks for transporting their goods.

Life safety standards have been directly influenced by the evolution of the automobile too. Today, we take safety precautions in making certain we keep vehicles on the road and away from pedestrian traffic and a certain distance from buildings. Bollards and roadblocks are only a few examples of site deterrents necessary to limit, control, and restrict access to vehicles. Similar approaches have taken a more aesthetic approach. Instead of bollards, large concrete letters are a disguise for an anti-ram wall in the Arsenal Stadium in London, UK as seen in Figure 1.

Figure 1 Oversized lettering of ARSENAL used as an anti-ram barrier.

Source: Getty Images[3]

Keeping vehicles away from a secured area has also become a life safety design concern that has emerged over the past few decades. Vehicles have now been used in a number of instances as weapons against people and buildings. It is crucial when designing security measures for certain buildings that a specific vehicle setback is achieved and there are design elements constructed and installed that prohibit a vehicle from entering specific areas. The protection would limit the damage from a vehicle-borne explosive device, or VBIED. A building offset might also be established necessary for individual factory buildings that might be working with explosive

[3] Michael Havis, *Arsenal's Emirates Stadium has a genius defence against terror that nobody noticed,* Daily Star. March 2017. https://www.dailystar.co.uk/news/latest-news/599562/arsenal-emirates-stadium-terror-defence-shield-football

materials. In this instance, the offset would contain the damage in the event of a possible explosion.

The commercial airplane has allowed for increased international travel across the world. Larger airports were soon needed to keep up with the demand for international travelers. Airports today are critical infrastructure elements of economic development to a community to its surrounding area have become popular, potential targets for terrorist attacks due to high concentrations of people. For protective reasons, there are constant demands for airports to have state-of-the-art safety features, security, and defensive design.

The dramatic increase of international travelers meant that there was also a need for national governments to represent them and their safety in a time of need. Rather than having separate, secure terminals, hotel and other buildings where people of various nations gather collectively, the responsibilities to represent citizens' interests, safety, and security fell upon their own government's embassies. With the increase in terrorism, the typical embassy duties changed from having strictly international political relations to incorporating new building space for international citizens to occupy during periods of unrest or danger. Earlier in time, problems in dealing with passport issues or times of crisis were dealt with through the host county's embassy. These problems created a concern for governments and designers as this situation far too often compromised the security of the building. Eventually, this concern for national safety and security became an expensive endeavor as many embassies relocated to new sites or were significantly renovated to better manage the influx of public users and increased security measures.

Development of new building materials pushed architecture to new creative heights and forms. Buildings were designed to be much taller where structures were supported by integral post and beam systems rather than through load-bearing walls supporting articulated facades. With new technology, concrete and steel creatively by architects and engineers to construct much taller high-rise buildings, create long-span structural systems, and new building forms. Over the past century, these materials and other structural products have evolved to become stronger and more fire resistant.

With the taller buildings heights and lighter but stronger building materials in use around the world, potential new problems called for new approaches to achieve greater life safety standards. Automatic fire-sprinkler systems were first installed to mitigate fire disasters in taller buildings, high pressurized underground water sources are now necessary. Means of egress restricted the maximum length of routes to allow occupants to exit safely are now connected to internal fire-stairs that exit directly onto the ground level outdoors. Taller structures needed to withstand new forces as stronger wind emerge as height increases. The tops of some buildings today must be designed to withstand winds at hurricane levels. Building material selection prioritized performative qualities over aesthetic appeal. Life safety standards will always evolve to adapt to new building designs, structures, and materials.

Globalization spread diverse thinking and international ideas across the world. in broader terms, globalization has changed the way architects and engineers design. New construction systems, building materials, and installation techniques were inherited from other countries through globalization. As indicated previously, the building typology for embassies is derived from globalization through the spread of various political agendas and the action and influence one agenda has upon another.

In earlier times, the he Industrial Revolution provided people with capabilities to improve their daily tasks. The use of steam as a source of power engines improved transportation methods via train and boat. This invention encouraged more trade and interaction between people and nations. This was the start of many technological advancements that led to globalization and the beginning of urbanization that would shape the way we think, design, and construct today.

The value and importance of life safety in buildings is paramount to advancing innovations and changes in architecture and engineering at a global level. With each and every change, architecture has always responded appropriately to the life safety needs. Could there have been better way to systematically anticipate changes and safety concerns?

2.2 The Development of Codes and Standards

Emergencies and building disasters can occur anywhere and typically happen when least expected. Building codes and standards are created, evaluated, empirically tested and used to limit, manage and mitigate the occurrence and impact of disasters resulting from building failures. One of the earliest and most widely used standards still in practice today is the code prepared by the National Fire Protection Agency (NFPA). Established in 1896, the NFPA was established by a group of citizens that called for uniform installation of sprinkler systems. Today the NFPA is comprised of thousands of volunteers and members that share a common goal of improving life safety throughout the world.

> *"The purposes of the Association shall be to promote the science and improve the methods of fire protection and prevention, electrical safety and other related safety goals; to obtain and circulate information and promote education and research on these subjects; and to secure the cooperation of its members and the public in establishing proper safeguards against loss of life and property."*[4]

The development process of NFPA standards is through a collaborative effort between the public, vested interests and the association. The NFPA standards are updated every three to five years using a process that encourages evaluation of existing standards, discussions and public participation with the belief that life safety is everyone's business. Any member of the public can submit input or drafts to the standards. These drafts go through a 4 stage development process; public input stage, public comment stage, NFPA technical meetings, and standards council action, as shown below in Figure 2.

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[4] National Fire Protection Association, *2017 NFPA Standards Directory, (*National Fire Protection Association, Quincy, MA, 2016), 4.

[5] Ibid, 10.

Figure 2 NFPA Standard Development Process.

Source: NFPA Standards Directory [5]

Since the development of the NFPA, other organizations and agencies have been established that are to dedicate to developing a comprehensive collection of construction codes. The International Code Council aims to create safer building and

[5] Ibid, 10.

environments to protect ‘the health, safety, and welfare of people’.[6] Since its conception in 1994, the ICC has published building codes to cover safety precautions that range from fires, mechanical and electrical issues, to specific building types and occupancy uses.

Similar to the NFPA, the ICC formed through a collaborative effort of multiple disciplines. The codes are typically updated every three years. It often takes longer for an area or jurisdiction fully adopt the new set of updates to the code. Public input to the code development process is mostly administered by non-profit organizational members. Below, is the eight-step process for the ICC code development shown in Figure 3.

[6] "About ICC,", International Code Council, accessed 2017. https://www.iccsafe.org/about-icc/overview/about-international-code-council/

Figure 3 The ICC eight step I-Code Development Cycle

Source: www.iccsafe.org [7]

Codes and standards are prepared and written using two standard two types of formats. Prescriptive code requirement are specific standards that must be met through design such as building setbacks or railing heights. Performance-based code requirements specifes how various components of a building must operate and perform. The performance-based codes allows for designers to create and submit new optional ways to code requirements that are not described within the adopted prescriptive requirements. Performace written code allows for more flexibility in

[7] International Code Council, *ICC Code Development Process: An Introduction to the Development of International Construction and Fire Codes (*The International Code Council), 6.

design and the potential to be more cost-effective through various possible alternative design solutions.[8] Today, performance-based design is becoming more readily accepted for use in modern building applications.

Many forms of hazards pose danger to buildings and occupants. Beyond environmental factors that include wind, water, and earthquake hazards, human factors include poor design, lack of detail or lapse in judgment. New technologies and emerging safety concerns including acts of terrorism also drive agencies to update and expand new content for codes that apply to current construction issues and conditions promptly. This process is labeled by some as a cause and effect pattern where an element of safety is compromised, and a tragedy occurs that is often costly and perhaps even fatal. Collaboration between disciples is imperative in analyzing safety concerns and developing new code protections. Life safety is and will always be a principal driver of planning and design in the built environment and architecture around the world.

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[8] V.I. Soebarto and T.J. Williamson, Soebarto, "Multi-criteria assessment of building performance: theory and implementation." *Building and Environment: Performance Simulation:Current State and Future Issues*, no.36 (2001)July: 681-690, doi:10.1016/S0360-1323(00)00068-8. Accessed 2017.

Chapter 3: Design and Life Safety Timeline

Historically, life safety standards have been around for quite some time and will continue to shape the built environment around us into the future. It is said that the first standards for life safety regulations came from the Code of Hammurabi in 1754 BC. King Hammurabi code decreed that the architect is responsible for any deaths that were to come from a building collapsing.[9] Today's standards have evolved dramatically from these principles to insure occupancy and public safety.

By the turn of the 20th century, the NFPA had established itself with its mission as 'establishing proper safeguards against loss of life and property by fire.'[10] The NFPA was still in its infancy with only one committee that addressed the importance of life safety by prioritizing life safety over property protection. Soon thereafter, other third-party public safety agencies started to form. They would report their findings on various life safety topics to the NFPA. The life safety standards developed throughout the 20th century have shaped the built environment towards environmental and fire resistant designs. It was not until the end of the 20th century that there was a focus on explosions and blasts in buildings resulting from acts of terrorism. Amongst the many life safety codes and standards, there are other additional resources available that are used to help improve building standards.

The incidents brought up in this chapter are a few events that have had an impact on the development of life safety standards in the 20th century. Each of the following briefs provide a setting along with circumstances around the time of each specific incident, a description of what happened; why the incident occurred, and each concludes with how the incident changed life safety standards at the time.

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[9] Nowak, *Making Buildings Safer for People.*

[10] Paul E. Teague, *Case Histories: Fires Influencing the Life Safety Code*, (Quincy, MA, 2009) 1147-1159.

3.1 Iroquois Theater Fire, 1903

The Iroquois Theater fire is still today the single deadliest fire in the U.S. During a play, one of the stage curtains caught fire and the fire spread rapidly throughout the building. The occupants at the time rushed to the exits only to find that some of them were either locked or could not open because the doors swung inwards. The fire lasted eight minutes and more than 600 people lost their lives. Following this tragedy, new design considerations were recommended that applied to all public theatres. Panic bars were required to be installed on all exits and exterior doors. All doors were required to swing outwards in the direction of egress. Illuminated exit signs were required to show the nearest exit.[11]

3.2 Triangle Shirtwaist Fire, 1911

The Triangle Shirtwaist factory was a busy factory in downtown New York City. The factory housed hundreds of workers in the 10-story building. A fire was reported on the eighth floor coming from a bin filled with clothes. The fire spread after attempts to put it out failed. As the fire spread, the people inside were trapped because one of the staircases was locked and the fire escape attached to the building was overcrowded and began to detach from the building.

Egress routes were not a priority in the building design. Per code at that time, the building should have had three interior staircases. The architect designed two interior staircases and had managed to reason that the exterior fire escape would suffice as the third, even though the fire escape did not reach the ground level. The architect had also deemed it unpractical for the factory doors to swing outwards so all the doors in the factory swung inward, opposite the direction of egress. The lack

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[11]. "A Tragedy Remembered", *NFPA Journal, 75-79*, ttps://www.nfpa.org/-/media/Files/Public-Education/By-topic/Occupancies/iroquois.ashx?la=en&hash=D6155182BA906E6C7A2B7B1190022C53C5D9616E.

of adequate egress routes, commotion from the fire, and smoke accumulation in the building caused many people to climb out of the windows and fall to their deaths. In the end, the fire had taken almost 150 lives.

The NFPA held their Annual Meeting in the following months, the major fire at the Triangle Shirtwaist Factory was at the center of discussions. The need for improved fire escapes was among the topics presented at the meeting. The exterior fire escapes were made of iron which, when quickly heated, will soften and become malleable under normal stresses. The structural framework of the fire escape will fail causing the structure to collapse.

The NFPA formed the Committee on Safety to Life in 1913 as a result of their Annual Meeting. At the following national NFPA meeting, the Committee on Safety to Life committee presented its findings and suggestions to update the building code. The report submitted by the committee focused on providing adequate egress routes, improving specifications on exterior fire escapes, and stressed the importance of installing automated fire-sprinkler systems.

The discussion on exterior fire escapes remained a primary focus for the Committee of Safety to Life's work. The committee believed that all necessary egress routes per code should be designed on the interior of the building. Fire escapes on the exterior of a building should not be used as a primary egress route. The committee wrote,

> "*Admitting . . . that a fire escape on a building is usually an admission that life is not safe in it, the fact remains that the outside fire escape is the commonest special provision for escape . . . [and] this Association should determine upon proper precautions for such escapes, and use its influence to have them adopted and enforced.*"[12]

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[12] Ibid

In 1918 a consensus was made to publish and distribute the committee's findings on exterior fire escapes and open staircases emerged. The nationally published pamphlet was titled "Safeguarding Factory Workers from Fire." This document, along with others, are the foundation of today's *Life Safety Code*. The Committee on Life Safety expanded interests and influence substantially over the following years. Professionals from various disciplines were represented in the NFPA through membership and group associations. The diversity of the members in the NFPA expanded the interests of life safety to other aspects of building design. The early studies and research of the NFPA were published into guides that was used in building design. The publications lead to NFPA's first issue of building codes called *Building Exits Code*.

3.3 Cocoanut Grove Fire, 1942

Built in 1916, the Cocoanut Grove nightclub was one of Boston's most popular clubs. A fire broke out in the single story building during one of its busier and over crowed nights. Lack of enforcing the NFPA's *Building Exits Code* directly resulted in the death of more than 450 people that were trapped inside.[13] A report of the incident was written by Robert S. Moulton, the Secretary to the Committee on Safety to Life. It concluded that the building design neglected to adhere and adapt to the building code which resulted in the deaths of many people.

The report from the fire commissioner stressed that the cause of the fire is less important than the inadequacy of proper egress. Access to the exterior doors was blocked which slowed down people trying to exit or, in some cases, trapped them inside. Some of the doors were locked and others were hidden behind the false walls. The fire spread from the lounge area to the foyer and main entrance engulfing the combustible decorations along the way. The people inside rushed to the front entrance in hopes to get out of the building. The only way out from the front was through the revolving doors. The large rush of people and the mechanics of the

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[13] Teague, *Case Histories.*

revolving door caused the doors to jam and did not allow for everyone to escape in time. Many people died at the entrance of the building, only feet away from their safety.

The lessons learned from this incident again highlighted the importance of designing proper means of egress. World War II postponed the NFPA Annual Meeting in 1943 which delayed changes to the code for another three years. The next NFPA code changes included installing swing doors within twenty feet of any revolving door, installing proper stairway enclosures, and requiring the use of fire-resistant decorations and interior finishes.

3.4 Our Lady of Angels Fire, 1958

All types of building typologies are subject to fires. The fire at Our Lady of Angel School was a reminder that fire safety needs to be practiced in all building designs. The school was two stories in height and had other building additions attached to it. The additions included a two-story annex and separate detached roof-framed building.

The fire started in the boiler room in the basement of the building. There was a delay in the alarm system to warn the occupants of the school that there was a fire. This delay allowed the fire to spread to the stairwell and to the second floor. Poor ventilation caused a large concentration of dense smoke to build up in the hallways outside of the classrooms. The buildup of heat and smoke in the hallways broke the transoms on top of the classroom doors. As a result, ninety students and three nuns died in the classrooms that caught fire.

In the aftermath of the fire, the Los Angeles Fire Department mandated that schools conducted regularly tested fire drills. The report concluded that the fire at Our Lady of Angel School exposed the vulnerability in popular school building systems against a fire safety. It was recommended that fire drills be routinely practiced throughout the school year. The reported also stated that the use of automated sprinklers served as a source for fire protection because sprinklers provided the best chance for suppressing a fire. Code changes reflecting this fire came at the Association's next Annual Meeting in 1961.

The *Building Exits Code* was reorganized in 1966. The new *Life Safety* Code addressed the desire and installation of automated sprinklers once again. The code updated automated sprinklers use in building design which increased the allowable travel distance to the nearest exit from 100 feet to up to 200 feet in sprinklered buildings.

3.5 U.S. Embassy Attack, 1983

In the early 1980s, the Lebanese government experienced a civil war. U.S. and European personnel were going to Lebanon as peacekeepers in support of the local government. Rebel forces apposed international influences in Lebanon and in 1983 a bomb exploded adjacent to a four-story building that was being used by over U.S. Marines and other personnel. A suicide bomber drove to the entry gates and detonated a vehicle-borne improved explosive device (VBIED). The explosion was strong enough and close to the building that it obliterated lower structural components causing the four-story building to collapse. Over 200 U.S. service members died in the attack.

There was another attack on the same day against French personal that were also in Lebanon at the time. Another VBIED was used on a French barrack that killed over 50 French service personal and government representatives.

An investigation into the inncident found that the building and site were not suitable for the barracks specifically with the heighten tensions in that region. The land was flat and easily accessible to both vehicle and pedestrian traffic. The building's location near the airport exposed the building to potential threats. The use of vehicles as an explosive device was not new at this time, howeverall building designs, specifically diplomatic typologies, did not anticipate VBIEDs.

A report was produced by Admiral Bobby Ray Inman following the attacks. The report focused on issues from the current assessment of U.S. diplomatic structures. It was called the Inman Report and its recommendations became standards for design and construction of future diplomatic posts across the world. The Inman Report is discussed later in Chapter 5.

3.6 World Trade Center 1993

VBIEDs are a threat to all types of buildings and structures. In 1993 a VBIED was used in an attack against the World Trade Center facility in New York. A van loaded with a 1,000-pound urea-nitrate bomb was detonated by a group of terrorists in the public parking garage under the South Tower. The act meant to bring down both towers and kill as many people as possible. This attack targeted a densely populated business high-rise block in New York City as its location. The explosion left a hole almost 100 feet in diameter at its epicenter on the garage's B-2 Level. Miraculously, the structure with stood the explosion and only six people were killed and just over 1,000 were injured in the incident.[14]

The power of the blast reached 150,000 psi with having a detonation velocity of 15,000ft/s. This force was immense enough to cause the reinforced concrete floor to fail and fall on to lower levels of the parking garage where the building's central utilitizes were located. The electrical power to the building was severed and backup generators were not able start-up due to flooding in the lower levels. Without power, hundreds of people were left trapped in the elevators in the garages and on higher levels in the buildings. The lack of adequate, alternative ventilation underground contained and encased the smoke inside the building pushing it to the top floors of both towers. The smoke also engulfed non-pressurized stairwells and elevator shafts hindered the response-time dramatically for people to evacuate the building and for first responders to assist in the evacuation process to enter.

An inspection of the building after the event deemed it necessary to retrofit structures and the weight of the building. Vertical and horizontal supports were installed to stabilize the building and to reinforce its building structure back to serve its functional use. The building resumed its functions shortly after the inccident because the effects from the blast were isolated to certain areas of the building.

A few things were learned from this incident. Issues pertaining to life safety and building design focused on:

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[14] Engineering Fire, *The World Trade Center Bombing: Report and Analysis*, (New York: Department of Homeland Security United States Fire Administration National Fire Data Center 1993), Accessed 2016. https://www.usfa.fema.gov/downloads/pdf/publications/tr-076.pdf.

Inconsistencies in the number and orientation of the stairwells confused those who were evacuating especially those that were visually impaired.

Ventilation issues in the building were inadequate. The immense amounts of smoke from the blast caused many people difficulty in seeing and left them struggling to breath. The smoke along with emotional shock caused many people to experience a variety of respiratory problems.

The explosion occurred indoors which had some unplanned consequences. Had the explosion occurred outside, the gases released from the blast would have had more space to escape. A blast within a confined space near combustible fuels increases the power of the explosion and can cause larger and more fires. Fires from explosions start from the heat that is contained from escaping the confined, compressed capsule and by igniting other combustible objects in the surrounding space. Parking structures are a critical design component that can expose this type of threat through the use of VBIEDs.

3.7 U.S. Embassy Bombings, 1998

By the end of the 1990's the U.S. had an imposing military presence in the Persian Gulf. Increased politcal tensions along with attempts to overthrow local governments were in retaliation against the U.S. and seen as an attempt by the U.S. to be a global hegmony. This perscpetive defined what would be one of the most horrific attacks on U.S. embassies.

One August morning in 1998, two large VBIEDs exploded outside two separate U.S. embassies. The U.S. embassy in Nairobi, Kenya and the U.S. embassy in Dar es

Salaam, Tanzania were the targets of the terrorist attacks. The explosions killed over 200 people, 12 of which were American citizens.[15]

The results of the attack proved to be devastating and called for an internal review on how the U.S. handles the protection for its international representatives. The United States General Accounting Office (GAO) provides investigations and evaluations for the United States. In response to the embassy attacks, the GAO published a report called Overseas Presence Conditions of Overseas Diplomatic Facilities. The goals of the report looked to ensure the safety of its citizens abroad. GAO was asked to (1) assess the current conditions of overseas diplomatic facilities, including security, maintenance, office space, and information technology; and (2) to provide some preliminary observations regarding the Department of State's efforts to improve facility conditions by replacing existing buildings with new, highly-secure embassy compounds.[16]

The report concluded that many of the department's facilities did not meet physical standards. A graph of the data is shown in Figure 4. As part of its purpose to improve safety measures, this report influenced Congress to fund the upgrading of embassy and consulate buildings worldwide. Although the Inman report was accepted and adopted by this time, its recommendations had not been followed through or used until after the 1998 bombings. The Overseas Presence Conditions of Overseas Diplomatic Facilities report specified what diplomatic structures that did not meet the standards of the Inman Report and provided a way for Congress to fund the upgrades.

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[15] Jess T Ford, *OVERSEAS PRESENCE Conditions of Overseas* (United States General Accounting Office 2003), Testimony, Accessed 2017. https://www.gao.gov/assets/110/109741.pdf.

[16] Ford, *OVERSEAS PRESENCE.*

Figure 4 Percentage of primary facilities that meet or do not meet key physical safety standards.[17]

Source: GAO

3.8 Design Responses

Throughout the 20th century, the NFPA expanded its design standards by developing new models and codes that extend beyond fire protection. NFPA codes and guidelines now include Life Safety Code and the Code for Means of Egress for Buildings and Structures. Other organizations today are developing and maintaining additional or other safety standards for design in other aspects of life safety such as blast mitigation. This is especially true in government agencies with specialized building types more unique and life safety concerns. The Department of Defense (DoD) and the Department of Homeland Security (DHS), for example, maintain their

[17] Ibid

design standards for particular classifications such as building types and unique or more frequent life safety issues which are more prominent in their areas of work.

These events are only a selected few examples that have shaped life safety and security in the built environment during the 20th Century. Fire safety was a central concern during this timeframe and still is today. Developments in sprinkler systems, egress planning, and building materials have led to safer and secure buildings. In the 1980's and 90's, it was apparent that blast mitigation safety measures should be standard in building design for specific structures. Life safety and security are design driver in architecture. In the future, there will be other added safety and security that also shape the way, as architects, we design buildings. We as designers must proactively learn from previous design experiences and mistakes and anticipate future changes in life safety and security so that future tragic incidents do not occur.

Chapter 4: Alternative Futures of Life Safety

The future is uncertain and change is inevitable in any scenario. When planning for the future, one should ask what are the possibilities of the *futures*. The future is an array of various possibilities and uncertainties for everyone. By implying that there is only one future, one restricts themselves to a limited set of possibilities. The further one ventures into the future the more uncertainties there are which lead to other future scenarios. These uncertainties shape societies and define various cultures that we will live in today. How will we travel or move from one place to another? Will there be new types of diseases? How will cities develop or evolve? These questions begin to shape future scenarios in the built environment.

Each and every scenario has different drivers which have different levels of influence on the future. The drivers lead to different future outcomes. The rationale of these scenarios can either be supported or invalidated through adequate research and data collection. Accurate and substantiated data serves as factual evidence that acts as the driver or disrupter of a future scenario. Accurate data evaluated objectively will provide trends, trajectories, or applications that can be used as evidence to support the occurrence of a future scenario by anticipating emerging issues. A designer can form a preferred future when applying the data gathered with different possible scenarios collected by the clients and design team. The preferred future approach to safety and security in design can offer more accurate foresight into a direction towards an anticipated future.

Once the designer forms the preferred futures, the questions then become, how does one reshape the present so that it benefits the preferred future? What must happen to make that future a reality? Sohail Inayatullah's provides six pillars of future thinking which helps to outline and define future scenarios and James Dator's alternative futures model creates a preferred future narrative to pursue. Each approach in the study of the futurism can be applied to a number of fields of inquiry from business models to marketing projections. The exploration of future scenarios for this specific inquiry is to focus on five life safety drivers: technology, building materials, access to the site and structure, occupational health, and governance. Analysis of these drivers an insight into the possible future and formulate a preferred future narrative that will be a guide to safety and security in future design scenarios.

4.1 Six Pillars Approach

The 6 pillars approach framework helps one form preferred futures and is developed by Sohail Inayatullah, a renowned future studies researcher.[18] Developing the alternative futures encourages a multidisciplinary effort that involves other knowledgeable and experienced people. Developing a future scenario utilizes the information and perspectives of various stakeholders for the project. The implementation of the preferred future to be achieved within a broader, yet more highly refined plan and approach. The six pillars are described below.

4.1.1Mapping

The first pillar is defined as mapping. This process establishes the initial framework of a preferred future. There are three compontents to mapping which is represented by a triangle as shown in Figure 5. One corner of the triangle is the image of the preferred future, the second corner are the drivers that help push towards the preferred future, and the third is the weights, or resistors, that detract from the preferred future.

The image of the preferred future is the realm of initial thought and ideas that encompass what the future will be. This process enables the participant to envision the desired outcome. The drivers are those supporting elements that encourage moving the present towards the preferred future. The weights serve as the elements that prevent the preferred future from occurring easily.

In the case of life safety in design, one could imagine a future that advances life safety in the built environment to become more automated through real-time data collection. Drivers in that future represent advancements in digital technologies and

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[18] Sohail Inayatullah, "Six Pillars: Futures Thinking for Transforming," *Forsight,* no. 10 (2008): 4-21, doi:10.1108/14636680810855991.

improve collaboration between disciplines in the building design. The weights that oppose this future can logically be the over-abundance of older built structures, increase in rate and intensity of natural phenomenon (storms or attacks), or lack of public interest in life safety.

Figure 5 Future Triangle that sets the framework for a plausible future.

Illustration: Author

4.1.2 Anticipation

The pillar of anticipation views possible changes that may occur in the future. What are disrupters to the future scenarios? Emerging issues analysis is a type of strategic planning. It focuses on uncovering and identifying disruptors to the preferred future to minimize the influence of the emerging issue and increase preparation for the challenges it may bring. These are discussed in greater detail in later sections of this document.

Life safety in design is always anticipating the emergence of possible changes in the future regarding the built environment.   The five drivers identified in the following sections are anticipated as the primary influences of life safety. An emerging issue that may arise might address the high density living and working conditions of the future as an example.

4.1.3 Timing

The pillar of timing analizing the changes to a future scenario as it reflects to various patterns already occurring. Inayatullah suggests there are a few different patterns emerging for the future. The pendulum pattern as one example represents a shift from organizational, corporate and governmental centralization to decentralization. A linear pattern of change represents a pattern of positive change in which everything improves over time. A cyclical change is a similar concept to address decline. A spiral pattern of change represents a transformation into the future but, where some of the past stays the same. [19]

A designer can make a meaningful change to influence the future by understanding the patterns of change in the drivers mentioned earlier. The development of life safety standards are cyclical process. Architecture that we deisgn today is a direct response not only to incidents of the past but in anticipation of future incidents with the intention of preventing them. One of the first signs of this cycle is the presence of knowledge or harms to building safety. This awareness brings concern to improve life safety or adopt new safety codes. This level of advanced thinking brings attention to the potential dangers inherent within tomorrow's "future" context of the built environment and their construction components associated with components of a buildings. As components are studied and critiqued, and new standards and codes requirements for protecting the public health, safety and welfare emerge and are published. These new codes will now steer the next generation of design and architecture. Figure 6 shows this cyclical process of life safety development.

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[19] Inayatullah, *Six Pillars*.

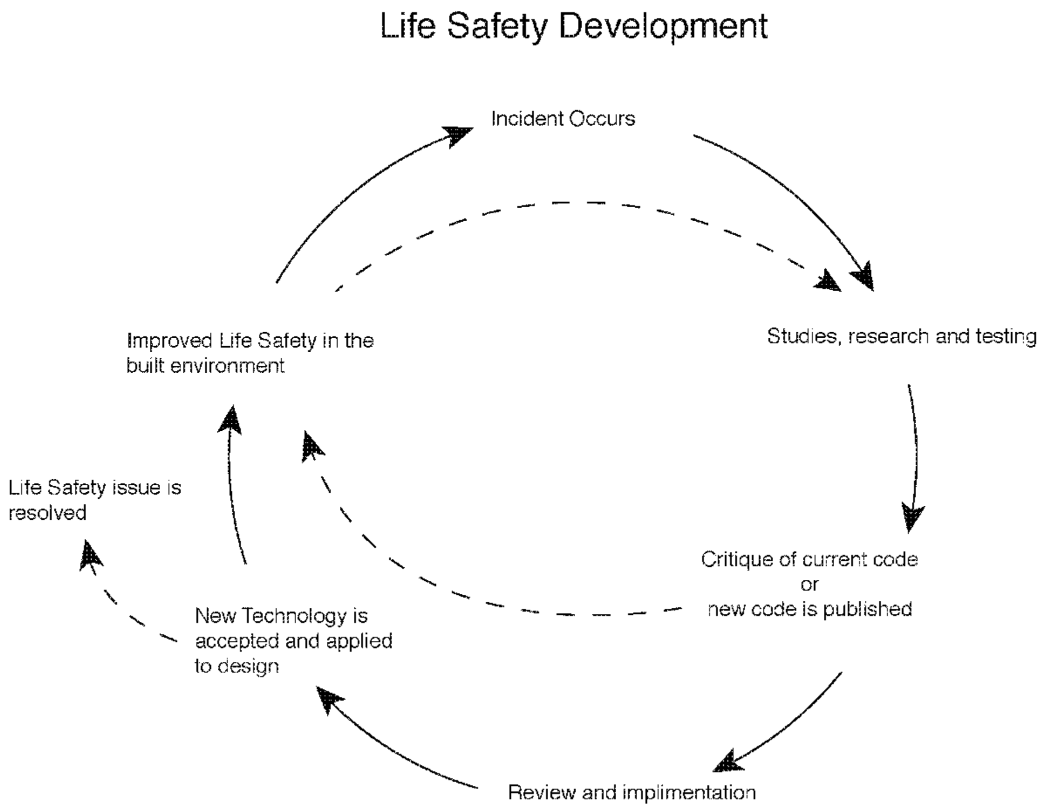

Figure 6 Life safety developments cycle.

Source: Author

As mentioned previously, life safety development in the built environment functions upon on a cycle where the built environment continually lagging behind the latest, most important safety standards. As an example, considering a time frame of 50 years sets the time frame anticipated for certain changes to occur. A goal for this research is to use this cycle to anticipate life safety changes in the built environment so that a tragic incident does occur and to shorten the lag time to implement new changes to the code.

4.1.4 Deepening

The fourth pillar is deepening. This pillar aims to expand and increase the understanding of issues the future at different scales. A Casual Layered Analysis (CLA) is an example of a method to approach the issues at the various levels of understanding. There are four levels of understanding in the CLA approach.[20] The first level is the litany which refers to the day to day activates and generalizations. The second level of the analytics refers to the systematic causes that has created the issue which look at the fixed systems of society. The third level layer of dimensional study is associated with a worldview or overall cultural acceptance of an issue. The final dimension of analytics is preparing a broader understanding and more metaphorical view of the issue, or issues.

The understanding of each dimension allows for a more completed and 'shaped' future. CLA provides different perspectives from the various stakeholders that are involved in the design process on the issues related to the preferred future. These multiple perspectives shape the future and broaden the discourse for a more conventional approach future planning.

4.1.5 Creating Alternative Futures

Once a future scenario has been framed, one can identify and consider alternative futures can be defined. What will produce the best case scenario? What is the worst case scenario? What happens if nothing changes and the "status quo" is retained? Inayatullah's pillar five reviews and examines each alternative futures. The organization of each future is then modeled using the data collected (drivers and weights) and the visions collected from the stakeholders. The systematic management and organization of this information helps others understand the plausible nature of each alternative future. Each optional future uses the data, or certainty associated with each set of circumstances, to identify the range of uncertainties that are drivers of each scenario. Ultimately each scenario has various levels of uncertainty and each of the drivers have different levels of influence on the future. Each scenario brings opportunities for the designer to create innovative

[20] Inayatullah, *Six Pillars*

approaches to possible future scenarios. The four futures approach is discussed in section 4.2.

4.1.6 Transforming the Future

Pillar 6 is envisioned to identify the most preferred future. Once alternative futures are created and analyzed, thoroughly crafted a consensus must occur amongst participants in the process as to which future or futures are used as a framework for an implementation plan. When there is agreement on a preferred future amongst the stakeholders, then that future is used as a basis for implementing the design. Agreeing on a chosen preferred future can be difficult amongst a large group of people. Often, a compromise must occur amongst the stakeholders; thus the preferred future ultimately may be a combination of two different optional scenarios.

4.2 The Alternative Four Futures

The four alternative futures define the different scenarios that involve various projections of the future as defined by the drivers. The alternative future is not meant be the exact predicted future but instead sets forth a model for understanding the implications current life safety drivers and their projected influences on the future. In other words, it provides a model that defines an end goal which makes the designer more aware of the design implications today and its effects towards achieving the preferred future scenario.

How does one predict the future and the necessities it requires? The short answer is that no one can correctly predict an exact future. The drivers of change, technology, healthcare, climate, etc., are constantly altering, assuming assumptions for the betterment of humankind. Uncertainties pertaining to these yet unknown drivers lead to many possible future scenarios. According to James Dator, a former professor of future studies at the University of Hawaii at Manoa, future scenarios are categorized into four groups. Each group represents a specific perspective on the preferred future. They are *Grow*, *Collapse*, *Discipline*, and *Transform*.

The *growth* future assumes we will find solutions to today's problems through known and unknown the drivers and continue to grow to better our societies and cultures. The *collapse* future represents the opposite of growth where society does not discover a solution to particular problems and is in a general decline. A *disciplined* future postulates a constant rate; not much change or innovation occurs. A *transformed* future develops a scenario that is conceptually new to society. An example of this is the U.S. embassy in Iran. There is no physical building for the embassy, but rather all the program needs for that embassy are done through a digital online format. This creates a new form of an embassy, a digital embassy.

This thesis forecast many man-made drivers pertaining to life safety. Not included are aspects including the impact of climate or natural environments. The primary (man-made) forces that drive the development of life safety regulations are support technologies, occupant health, access to the site, building material, and sociopolitical influences or governance.

Artificial intelligence (AI) is a gro exponentially expanding realm of technology being embraced by the general public. Within 50 years AI will be used daily in every setting assisting a majority of aspects in our lives. In the built environment, AI is used to help conceptualize a building project by analyzing data collected from a source to assist in design decision making in both performative and aesthetic applications. AI is used during post-construction to analyze building and site use. As an example, AI can be utilized to identify occupant traffic needs at different times of the day. AI systems can compute occupant traffic in different areas of a building which help identify spaces that will need more secure and safe design security measures.

The social well-being of a building's occupants has taken greater emphasis in design recently. People are no longer working in walled offices or cubicles that separate them from their coworkers and the rest of the building. Open, coworking spaces are preferred working environments in most of today's business models. This type of an open working environment emphasizes interaction between workers and functional disciplines within the office space. A visual or even physical connection to the natural environment is proven to be beneficial to the health and well-being of the workers. Access to natural elements such as trees and water has proven to lower levels of illness, increase work productivity, and promote a safe working environment.[21]

The way we access buildings has also changed over the past century. Automobiles have become a personal commodity and preferred means of transportation which has led to increased traffic, longer commutes, and the necessity for parking structures to address and maintain parking needs. Automobile trends currently are shifting towards more sustainable transportation means such as electric cars and car share opportunities. Other sustainable approaches to transportation include bike-friendly infrastructure designs and mass public transportation in dense urban areas.

In some situations or settings transportation is not needed to provide access to a building. The U.S. Embassy in Iran mentioned earlier uses digital technologies to reach out to its users. The digital embassy provides all the necessary functions of a typical embassy, however, however work and services are performed and conducted online. Digital technologies in the future will transport us digitally to places across the world with the use of virtual reality and AI assistance.

Drones are now being used for multiple purposes ranging from recreational entertainment to confidential military surveillance. Drones pose both harms and benefits to public safety. The current principle value of drones is they are easily accessible, inexpensive, highly maneuverable, and replaceable. They can monitor areas from far distances and be able to identify potential harm as part of an early detection system. It is also important to note the opposite; drones can easily be used to encroach in areas that are designated as a no fly zone. This is readily

[21] Louise Chawla, *Improving Health and Wellness through Access to Nature*, (American Public Health Association 2014) 24 (1): 196.

apparent today in instances where drones are used to illegally transport items into prison facilities undetected. Another concept for the future use of drones is for personal aviation. Pilotless larger drones can be used as a self-taxi service for the public. The designs of drones are tested at different scales to transport materials and even people. Aviation regulation is still vague on the use of drones, and thus design measures should anticipate the use of and protection from drones in the future for surveillance and transportation means.

Building materials play a vital role in life safety in the built environment. Steel and concrete have defined the architecture of the past century. Today, material science studies in nanomaterials produce nano-architecture structures. These structures are incredibly lightweight with the strength of steel. The nanomaterials can be used in glazing applications which can make the window more impact resistant. Concrete derived from cellulose nanocrystals increases concretes strength, impacts resistance, and flexibility. This will make building structures more resilient over time and to different forces such as blast waves. Material research has focused on redirecting the elastic force caused from blast waves and earthquakes away from critical structural members. Thin steel plates with microscopic geometric etchings allow it to refract and dissipate the elastic waves away from the steel structure. This material technique can save buildings from structural failure.[22]

The government is a significant driver in securing life safety in the built environment. Government within this context refers to the national government and the governing structure of the agencies that form today's accepted building code. Both play a pivotal role in developing guidelines for a 'safe' building. The agencies continue to conduct valuable research towards advancing safety for people and buildings. The national government role is crucial as it provides a large portion of funding for

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[22] Abeer Samy Yousef Mohamed, *Nano-Innovation in Construction, A New Era of Sustainability*, (2015 International Conference on Environment And Civil Engineering: Pattaya, Tailand, 2015), 1-20. http://ia-.org/siteadmin/upload/5714IAE0415416.pdf.

security measures in federal buildings. A part of the State Department Security Appropriations is used for construction and renovations to improve and maintain security conditions in their federal facilities. The amount appropriated in 1992 has been increased from over 400 million dollars to over 1.3 billion dollars by 2002.[23] This shows that the government's dedication to providing a safe built environment for its buildings and personnel is critically important.

		FUTURES			
		GROW	*COLLAPSE*	*DISCIPLINE*	*TRANSFORM*
FORCES	*TECHNOLOGY*	Accelerating	Stable	Focused	Complex
	HEALTH	Increasing	Disease	Diminished	Transcend
	TRANSPORTATION	Accessible	Luxury	Sustained	Obsolete
	BUILDING MATERIALS	Dynamic	Scarce	Regulated	Manifold
	GOVERNANCE	Collective	Provisional	Privatized	Holistic

Figure 7 Future scenarios and drivers of life safety.

Source: Author

As we know, there is no such thing as one future. The use of strategic foresight analysis helps narrow and define preferred futures. In turn, the preferred futures help us find a solution today in anticipation for tomorrow's problems. To be objective, the analysis should incorporate multidisciplinary effort from a team of disciplines knowledgeable of the issues at hand. A collaborative effort ensures there is a robust framework to shapes the decisions made in creating the preferred future. We also know "structure" changes behavior. By changing the structure that we

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[23] Susan B. Epstein, *Embassy Security: Background, Funding, and the Budget, (*Congressional Research Service, 2001), 1-14.

approach life safety, the design can change the behavior through the environments that we live in. The first step in ‘changing the future’ is to change the story people tell themselves in thinking and speaking about the future. Change begins with a vision.

When applying a futures studies analysis, it is important to know that there is not one, singular future being set forth. There are many scenarios that can be extracted from data collection; and, used to guide and direct various perspectives undertaken and pursued by stakeholders. The goal supporting this analysis does not conclude with only one specific future. The goal is to create and establish a successful pathway to achieve the desired future. Successful paths result from collaborative, participatory processes where stakeholders surrounding the issue oversee the “futures” evolution, emergence, maturity and outcomes.

Chapter 5: Embassy Design

All buildings today are designed to respond to a range of life safety standards. Embassy building typologies are one of the most representative building typologies which is directly impacted by new life safety concerns, specifically through its design and architecture. An embassy is the official residence or offices of an ambassador from a country. The U.S. currently has 307 embassies, consulates, and diplomatic missions across the world.[24] Embassies are typically located in countries capital city or nearby district. Washington D.C. as an example has 176 foreign embassies alone. In each case, these buildings are designed to represent the ties to the host country while having a safe and controlled working environment in respect to each specific building location and its surroundings. Embassy buildings and its imagery have strong political meanings and embodiments in its design. An embassy's aesthetic most often conveys a political setting which can be visually sensitive to observers, yet take, absorb and repel harsh criticism from its host country. An example of this can be seen in the U.S. Embassy in Havana, Cuba the Cuban government installed one hundred flag poles with black flags raised in the front of the embassy. The flags were used as political propaganda and as a visual deterrent from the embassy in response to the changing relations between the countries at the time.[25]

Buildings visually speak whether or not a voice is desired. Embassy's speak on behalf of the nation or country it represents. An embassy's story tells about two

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[24] Amy Roberts, *By the Numbers: U.S. diplomatic presence*, (CNN Politics: 2013), Accessed 2016. https://www.cnn.com/2013/05/09/politics/btn-diplomatic-presence/index.html.

[25] Randal C. Archibold, *U.S. Outpost in Cuba to Step Out of the Shadows*, (The New York Times: 2015), https://www.nytimes.com/2015/01/21/world/americas/us-outpost-in-cuba-to-step-out-of-the-shadows.html.

country’s relationships with each other. It is important that embassies are perceived in a positive manner, specifically by its host nation. Embassies are one type of physical manifestation of a visitor nation abroad. They help provide services to both nationals and foreign nationals in the host nation. These services range from help with visa information, negotiate hostage situations, and build international relations abroad. Over time, the novelty of embassies has changed in both its appearance and functions. T This chapter describes and explains the purpose of an embassy and how safety and security are principal design drivers in embassy buildings.

5.1 What is an Embassy?

An embassy is a microcosm of the nation it represents. The embassy is a representation of a nation’s political power whose facility is as an additional means to progress its diplomatic mission on an international scale.[26] One additional physical manifestation of an embassy is its ability to exhibit and publicly express the unity between two political powers to the outside world. There are over 200 US embassies across the world.

In larger nations, there are also consulates which in many ways are similar to a satellite offices for the embassy. Embassies are typically located in a nation’s capital like Washington, DC whereas consulates offices are located in a nation’s major cities such as New York, Los Angeles, or Honolulu. Both types of buildings, embassies and consulates, take on different forms and styles that are symbolic of the country's relations with its host nation. Political buildings typically stand out visually from its surrounds, or they are nestled into the surrounding immediate context in which case they become hidden and almost hidden. Figure 8 shows the Consulate of the Marshall Islands in Honolulu. The official consulate is situated in a two bedroom apartment situated in a small three-story apartment building. This specific type of

[26] “What is a U.S. Embassy?”, Discover Diplomacy, https://diplomacy.state.gov/discoverdiplomacy/diplomacy101/places/170537.htm

political manifestation in architecture is an example of one extreme in design while the U.S. Embassy in Ecuador is an example of the opposite extreme.

Figure 8 Consulate of the Marshall Islands in Honolulu.

Source: Author

5.2 Development of Embassy Design

Embassy architecture matters. Social, political, and cultural issues surround and engulf embassies in throughout the design process and post construction. An embassy often symbolizes aesthetically the relationship between the two countries. Evolving from fortified concrete boxes to open forms, US embassies have seen significant changes to design approach and design since World War II. The symbolism behind an embassy can be publicly and politically received with open arms or be subject to strong criticisms. These views change over time, in sync with the country's respectful relations with another as well as societal views and needs of all parties involved. This chapter explains the changing aesthetic and design approaches to US embassies since the 1950's.

5.2.1 1950-1980

The US became increasing interested in global interests during post World War II. The designs of its embassies portrayed America's decision to separate itself as a major political power abroad. America's designs often contradicted the traditional social, cultural, scale, and architectural forms of the host country. The International

Modernist Style and design approaches were upsetting and provoked loathing towards the US. Embassies were the target of minor disruptions and protests. Protests were more common but, in some situations, violent attacks such as the burning of the U.S. Embassy in Islamabad in 1979 exposed the potential threats against U.S. federal buildings, specifically embassies.[27]

5.2.2 1980-2010

After the bombings of the U.S. Embassy in Beirut and Marine barracks bombing in 1983, a call to action was needed to address the safety concerns of U.S. diplomatic locations. The Inman Report was created to identify and address potential issues on U.S. buildings in foreign nations. The Advisory Panel on Overseas Security issued a seven-year plan that would increase the protection of 126 diplomatic posts across the world out of the 262 that were operating during this time.[28] This determination was characterized by three security issues. The first issue was whether the building satisfied current physical security standards. The second dealt with the construction of the building and in determining if the building shared a common wall with an adjacent structure. The third security measure assessed if there were other building tenants outside of the US government. When it was completed, this report established new building and design standards; it updated construction strategies,

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[27] Cameron W. Barr, *A Day of Terror Recalled 1979 Embassy Siege In Islamabad Still Haunts Survivors*", (Washington Post, 2004), http://www.washingtonpost.com/wp-dyn/articles/A15332-2004Nov26.html.

[28] Admiral Bobby Ray Inman, *Report of the Secretary of State's Advisory Panel on Overseas Security, (*United States Department of State, 1985), 1-68. https://1997-2001.state.gov/publications/1985inman_report/inman1.html.

and made recommendations regarding to retrofitting current facilities when and wherever possible.

The Advisory Panel agreed on six broad conclusions that are still accepted in today's planning for foreign U.S. diplomatic building programming:

> -- *The United States must control the buildings in which it does business overseas.*
>
> *-- Location is the paramount consideration in the avoidance of assault and penetration of every kind. Being on the busiest or most Fashionable Street or corner may have been an asset in earlier days; today it is a liability.*
>
> *-- Co-location with occupants whom the United States neither chooses nor controls presents a substantial risk for assault and penetration.*
>
> *-- Proximity is a vital concern when other buildings abut or are so close that modern electronic and audio techniques can make it extremely difficult to safeguard national security information.*
>
> *-- Age, architecture, and design are crucial to the ability to defend against penetration and assault. Many buildings simply cannot be upgraded to the standards that are necessary today.*
>
> *-- Adequate funding and new approach to overseas construction are essential. The old, business-as-usual approach cannot meet the new requirements.* [29]

The client must be willing to pay more for improved security measures. Applying all the recommendations and improvements addressed in the Inman Report would come

[29] "United States: Excerpts of Report of Secretary of State's Advisory Panel on Overseas Security." *International Legal Materials* 24, no. 4 (1985): 1175-183. http://www.jstor.org/stable/20692873.

with high costs that might even discourage funding for future projects. The use of the Capitol Budgeting system used a value-engineering method to cuts costs for the project while allowing for more flexible long-term investments from the government funds.

The findings of the report were never fully applied until some thought it was too late. Other attacks on US embassies still proved that existing facilities lack the proper safety and security measures. Three years after the bombings of U.S. embassies 1998, the Overseas Buildings Operations (OBO) published the Standard Embassy Design Program (SED). The SED program brought a swift standardized, one-size-fits-all process to the embassy design. The result created insensitive, unflattering designs that only isolated the US from its host nations rather than attempting to spread a positive political agenda.

The Department of State's Bureau of Overseas Buildings Operations developed the Standard Embassy Design that is now using for the majority of its capital projects in response to the recent threats and attacks on U.S. federal buildings. The SED document lays out the process to plan, design, and construct new embassy compounds incompliance with strict safety and securty measures. It consists of a series of documents, including site and building plans, specifications, design criteria, an application manual describing adaptations to specific projects, and contractual requirements.

US embassies designed using the SED process were criticized for their approach that often distanced and isolated itself from the physical and environmental context in which the building is located. Ultimately the one size fits all approach taken by the SED program went against the US mission which was to help spread America's diplomatic agenda. The SED program was not successful in any regard and was short lived. Embassies built under the SED guidelines were most often isolated, unappealing compounds. The buildings themselves showed little relation to US architecture, the context and environment of the host country and its focus was more on security than diplomacy. The U.S. Embassy in Quito, Ecuador and the U.S. Embassy in Astana, Kazakhstan are examples of the standardized template of the SED guidelines as shown in Figure 9 and Figure 10.

Figure 9 U.S. Embassy in Quito, Ecuador built using SED guidelines.

Source KCCT Architecture

Figure 10 U.S. Embassy in Astana, Kazakhstan using the SED guidelines.

Source KCCT Architecture

5.2.3 2010-Present

There are two main factors that influence the value of U.S. embassies today; wealth and affiliations to culture.[30] These factors determine the design response of an embassy. Embassy's today have more considerable influence in international relations that support existing relations or, sway other country's political intentions. By creating new forms and design approaches, embassies can have more recognition through context rather than overpowering symbolism most embassies are recognized for.

In May 2009, Senator John Kerry discussed the aesthetical dilemma of U.S. embassies that were being built.

> *"We are building some of the ugliest embassies I've ever seen. We're building fortresses around the world. We're separating ourselves from people in these countries. I cringe when I see what we're doing"*[31]

This calling led to another change in approach embassy design once again. The American Institute of Architects (AIA) offered their support and considerations for improving the SED guidelines. The OBO, with help from the AIA, recently published the Guiding Principles of Design Excellence in Diplomatic Facilities in April 2010. This guide provides an improved facility assessment to building design. The program does still lack detailed performative requirements and a set approach to designing embassies. The program is new and performance data still needs to be collected and

[30] Natasha Dimitrova Guenova, *Form Follows Values, Explaining Embassy Architecture*, (University of Tennessee: 2012), 155.

[31] Philip Kennicott, *Breaking the Diplomatic Ties That Bind Design* (The Washington Post, July 19, 2009). http://www.washingtonpost.com/wp-dyn/content/article/2009/07/16/AR2009071604601.html

analyzed to see the actual value of the Excellence program. Figure 11 shows the timeline development of the OBO design guidelines from 1998 to 2016.

Figure 11 Timeline of the Department of State Bureau of Overseas Buildings Operations Standard Embassy Design, and Excellence.

Source: GOA

Successful embassy design balances aesthetic and security while anticipating changes to that balance in future scenarios. The designs guidelines of the Excellence program were prioritizing appearance over security compared to previous guidelines.

The new approach to U.S. embassies through the Guide to Excellence was viewed by some as being too focused on aesthetic rather than on security measures.[32]

One of the more recently completed projects completed through the Design Excellence program is the U.S. Embassy in London. The 500,000 square foot facility stands alone, separated from its surrounding context on a 4.9 acres site.[33] Designed by Kieran Timberlake architecture firm, the 12 story glass cube achieved high security and sustainability standards.

The building sits above landscaped circular terraces that elevate and raise the building well above the street level. The back side of the embassy has a water feature which acts as an aesthetic feature and a safety feature to further the setback and possibilities of a vehicular attack from the rear of the embassy. The façade of the embassy is constructed of six inch thick ballistic glass, symbolic of the transparency of democracy as shown in Figure 12.

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[32] Michael Z Wise, *House Committee Questions State Department's Embassy Design Program*, (Architect Magazine, 2014), http://www.architectmagazine.com/design/house-committee-questions-state-departments-embassy-design-program_o

[33] Rowan Moore, *London's new US embassy: a very diplomatic America on Thames*", (The Guardian: 2017), https://www.theguardian.com/artanddesign/2017/dec/17/us-embassy-nine-elms-diplomatic-mission-hidden-teeth.

Figure 12 U.S. Embassy in London, designed using the Design Excellence Program. Source: Kieran Timberlake

Deemed a success through the Design Excellence Program, the embassy does have some problematic drawbacks. The project was delayed and projects costs well exceeded its 800 million dollar budget by almost 250 million dollars and. In context with its surrounding London cityscape, the embassy stands alone, separated juxtaposed along the River Thames.   The large geometric form sits apart from the surrounding high-rise and podium buildings imposed on its site.

5.3 Embassy Typologies

Embassies come in different shapes and sizes. Each provides different amenities and functions specific to the site and location. There are four types of embassy building typologies; the island, the compound/complex, the shared embassy, and the virtual embassy. This section identities and describes each of these different typologies.

5.3.1 The Island Embassy

As earlier indicated the new U.S. Embassy in London is a standalone glass cube that sits elevated above the ground along the River Thames. The building provides the 100-foot standoff distance and perimeter security without over-hardening its context and surroundings. However, this location separates the building from its surrounding context. Due to site, size limitations, there is no public parking; but employees can park underneath the building. There is one public entrance for pedestrians with a detached checkpoint area separated from the embassy building.

The design intent was to portray a transparent US government and openness with the use of the glass façade and landscaping. This might be successful as a design concept however the building still isolates its self within the context of its setting. There is little indication that the design extends in any manner on into the city.

5.3.2 Compound / Complex

A compound or complex typology contains all the amenities and program space an embassy within an enclosed area or community. These complexes often contain a wide range of programs and buildings that are walled off from the public. The U.S. embassy complex in Beijing is on a 10-acre site that has six separate buildings; an eight story chancery, three story atrium office building, marine security guard quarters, consular building, seven story annex, and parking structure. These buildings are surrounded by a blast rated, perimeter wall that acts as a safety buffer in conjunction with the surrounding landscape.

This is a more successful design to an embassy. The site is large enough to have its parking structure which can handle all the parking needs. The concept of a Chinese garden is a successful design response to the cultural context of China highlights the strong relationship that the U.S. and China share. The low profile of the buildings does not overpower the surrounding cityscape. The perimeter wall performance rather than prioritizing the aesthetic quality of the embassy and is not that welcoming to pedestrians walking by.

5.3.3 Shared Site

A shared site can either mean that multiple countries share the complex or more than one country work out of the same building. The Nordic Embassies in Berlin is comprised of six buildings on one lot. Five of the buildings are embassies that represent Denmark, Iceland, Norway, Sweden, and Finland. The sixth building is a shared structure with civic spaces such as an auditorium and canteen. The buildings were designed as a collective whole by architects from each of the represented countries. The exterior facades along the perimeter are wrapped in a continuous copper cladding. A geographically referenced courtyard that connects all the buildings on its interior. An aerial picture of the complex is shown in Figure 13.

Figure 13 Nordic Embassies, Berlin.

Source: www. architectuul.com

An embassy typology like this are achieved through the relationship of the countries that share the facility. The unique layout of the Nordic Embassies provides security through control. There is no parking onsite for either the public or employees. The minimal design highlights an open pedestrian environment on its interior with its broad and exaggerated pathways. The open space increases the sense of safety without the trying to impair visual access to the interior of the site. The ribbon wall that surround the site is used as a security feature. It can detract from the openness of the interior, however, a majority of the closed-off facade is surrounded by trees and is not imposing to the surrounding buildings.

5.3.4 Virtual Embassy

In times of tough political tensions and with the incorporation of modern technology, diplomatic relations can be achieved without the physical presence of an embassy building. The concept of a virtual embassy first started with the U.S. embassy in Thran, Iran. Due to harsh political circumstances, the U.S. found a way to begin to connect the gap between Iranian and American people. The embassy can be accessed anywhere in the world via the internet. The website states,

> *"This website is not a formal diplomatic mission, nor does it represent or describe a real U.S. Embassy accredited to the Iranian Government."*[34]

Although it is an unofficial embassy, it still provides educational platform with cultural and minimal citizen services. Any immediate help for U.S. citizens in Tehran can go the Embassy of Switzerland for assistance.

5.4 Embassy Design Approach

Architecture has a particular power and symbolism behind it, so important that the buildings themselves are viewed as a sign of power and control. The taking over or destruction of a significant building could show one's dominance over another. This destruction has been shown numerous times in history and continues today. Some of the most influential buildings internationally are a country's embassy. They hold special political powers of rights and immunities in a foreign country. Sadly attacks on embassies are not uncommon. Attacks on embassies range from protests to the use of VBIEDs that cause complete destruction of embassy buildings. As a results, the design approach to embassy design is under constant scrutiny as attempts to balance aesthetics and security have not been successful in the past.

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[34] "Why Virtual Embassy?", U.S. Virtual Embassy Iran, https://ir.usembassy.gov/tehran/

It is essential to look back at the history of embassies and how they developed both functional and architecturally. They will always need high safety design requirements and will always be changing in context to its international relations with other countries. Figure 14 represents the development of the embassy typology. The red building symbolizes the embassy, the black is security measures in the design, and the grey buildings represent public spaces. Different futures can dictate how we design and use embassies. They can continue to be modern fortified castles, or develop into a design that is responsive to the safety needs and building symbolism.

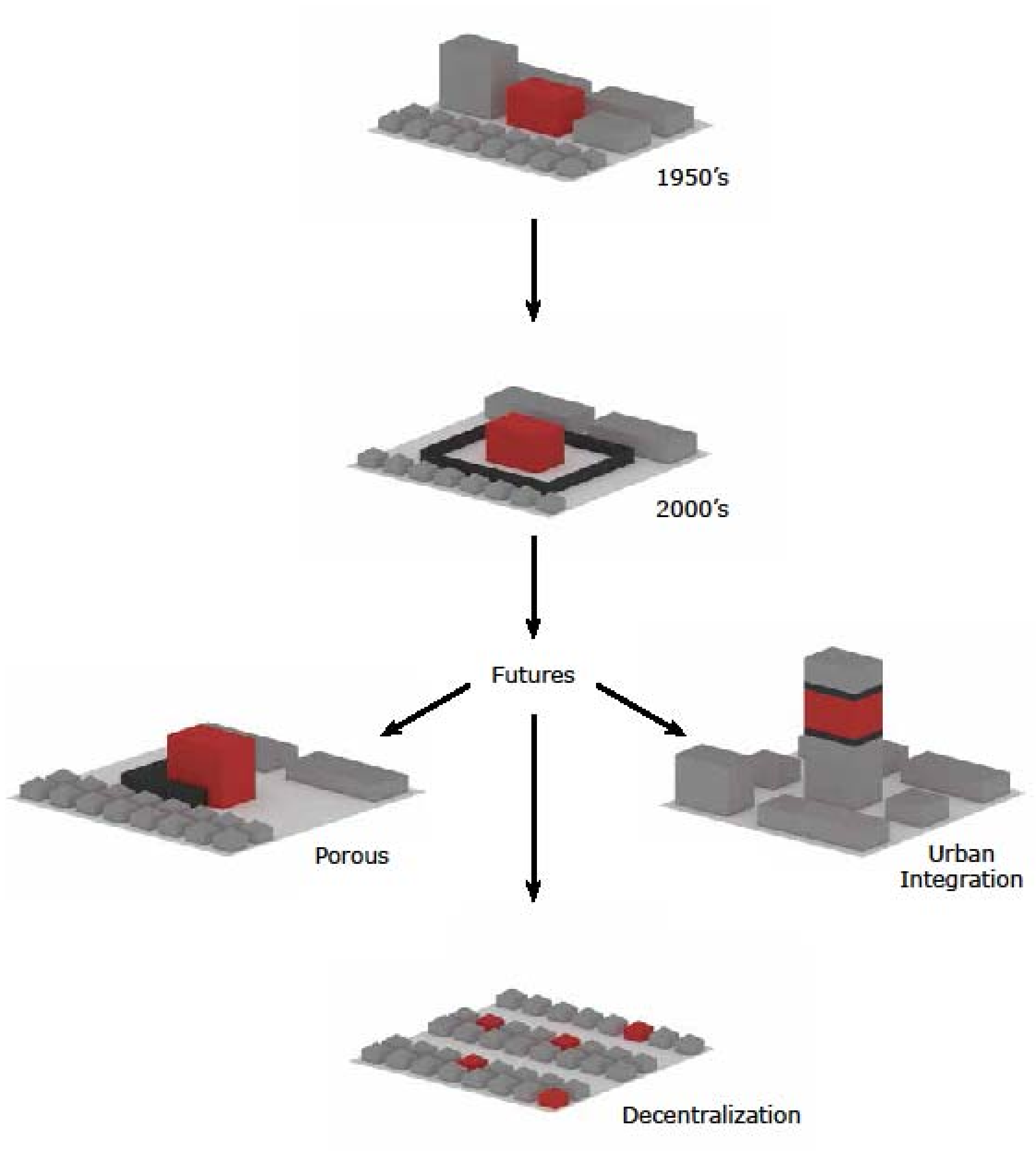

Figure 14 Development of U.S. embassy design approach.

Source: Author

What kind of democratic embassy do we want? People want to interact with democracy. It is a hands-on form of government that activates people rather than sedate and manipulate them. This is reflected in the performance of embassy buildings. Performance indicators for program, security, and sustainability are not specified but mentioned as part of the Guiding Principles of Excellence. The value of safety and security reads:

> *The safety and security of staff and visitors is paramount. Designs and construction will meet or exceed all security and safety standards and specifications. Architects and engineers will be challenged to design and develop ever improving methods, materials, and solutions and to thoughtfully integrate these into overall designs.* [35]

Security design guidance mentioned towards the end of the document reiterates the concerns for the safety of the facility and its users on a day to day basis. The guidelines call for professional blast consultants to collaborate with other design entities such as a landscape architect to innovated new ways to mitigate security measures. Applying a preferred futures design approach helps the designer and consulates find innovative ways to solve safety and security issues in the design.

[35] Guide to Excellence in Diplomatic Facilities. 17.

Chapter 6: Blast Mitigation

Blast mitigation design strategies influenced life safety standards and architecture in the 1990's. Events like the Oklahoma City bombing in 1995 and the bombing of the U.S. Embassies in Tanzania and Kenya in 1998 pushed for the need for design guidelines for blast resistant buildings. As a result, agencies such as the Department of Homeland Security and Federal Emergency Management Agency (FEMA) have published design considerations for dsign stategies against blast forces from both occupational hazards and terrorist threats. This chapter explains what a blast is and how it has changed architecture design and life safety in building code.

6.1 Blast Wave

Blast mitigation stategies are applyied in design with the understanding on what a blast is and how it travels through a building. A blast wave is a shock wave that is caused by a high order explosive. The shock wave is formed from compressed air that is forced outwards from the point of the explosion at pressures greater than the atmospheric pressure.[36] There are two types of explosives, low order and high order. High order explosives produce a supersonic over-pressure shock wave which are detrimental to buildings. Blast mitigation strategies anticipate the use of high order explosives. Examples of high order explosives include TNT and dynamite. Depending on the size of the explosive used, the shock wave can be seen with the naked eye.

6.1.1 Pressure and Impulse

Building performance in blast mitigation is designed to withstand certain pressures and impulses from a blast wave. The pressure caused by an explosion is far greater

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[36] David Cormie, Geoff Mays, and Peter Smith, 2009. *Blast Effects on Buildings.* 2nd. (London: ICE Publishing, 2009). 17

than the normal atmospheric pressure around us. This causes the blast wave to expand outward from the point of the explosion. The pressure from the explosion causes immediate injury to the internal organs as the blast wave passes though the human body. This possess a great threat to the lives of the people closest to the point of the explosion. The shock wave expands outward from the point of the explosion until the pressure equalizes back to normal. The pressure decreases exponentially over time and distance as seen in Figure 15 represented by the dashed line.

Figure 15 Diagram showing pressure over time.

Source: FEMA 426

The impulse a resultant of the overpressure. It is the total amount of energy that is exerted on the building.[37] Impulse is the measurement of forces that act over a short time, producing rapid changes in motion. The force on the building is at its highest when there is a shift from positive pressure to negative pressure on the building. At this part of the blast wave sequence, shift in pressures causes the building sway. The initial force of the blast wave pushes the building up and away. The building then sways back inward when the pressure decreases as shown in Figure 16. The swaying motions of a building can cause significant structural damage and even structural failure causing the building to collapse.

[37] FEMA 426, *Reference Manual to Mitigate Potential Terrorist Attacks Against Buildings; Providing Protection to People and Buildings." Risk Management Series. (*Federal Emergency Management Agency: 2003),

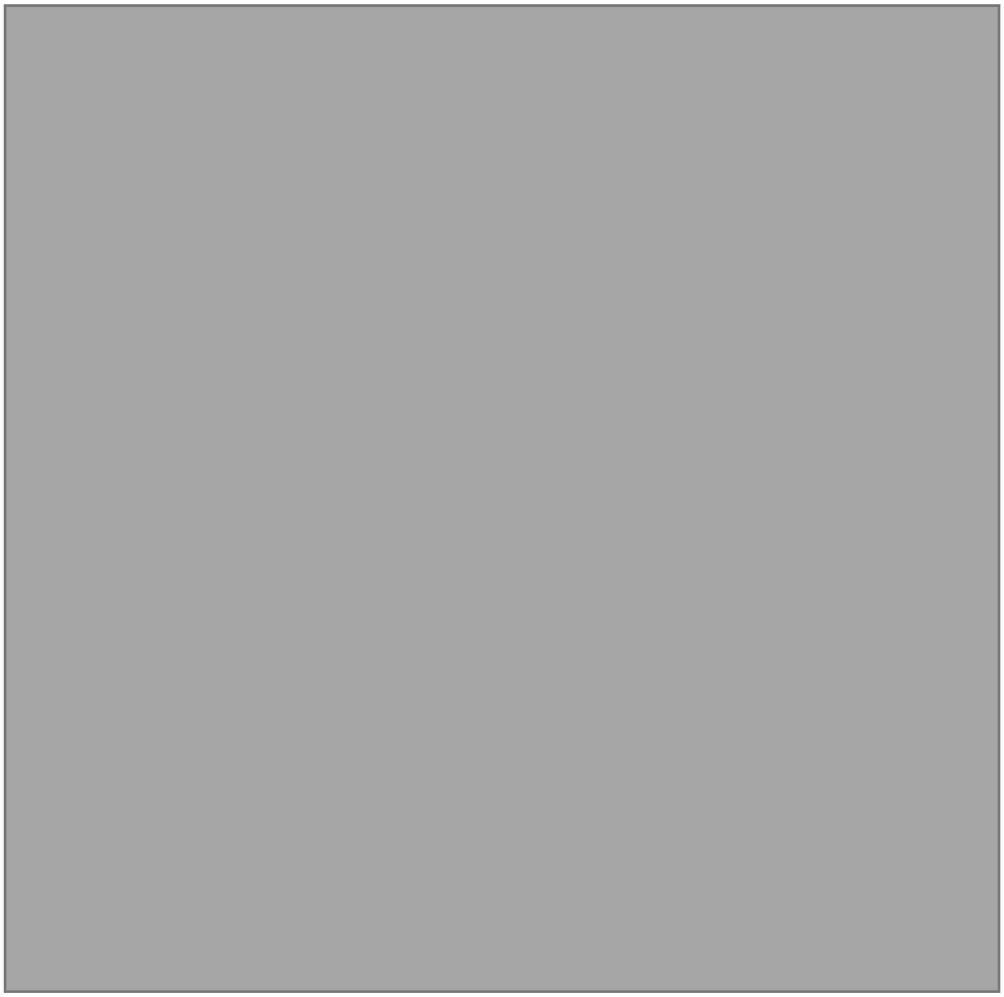

Figure 16 Blast wave pressure effects on a structure.

Source FEMA 426

6.1.2 Weight and Distance

When designing for blast waves, the structure should withstand a specific impulse. The impulse measures force applied to an object in pounds per square inch (psi). One pound of TNT is equivalent to one psi. One pound of TNT is used as a base comparison for the weights and power of any explosive type. Blast mitigation strategies might call for building components that can withstand a 10,000 lb. explosion. This tells the designer and consultants the performative requirements for that building component must withstand a force of 10,000 psi. The weight of the explosive device and the distance of the building or target are two factors that direct design considerations.

The weight of the explosive is directly proprtional to its power. Heavier explosives are more pwerfull than lighter explosives. Figure 17 shows the suggested setback distances against the different weights that can be used in explosives. If the blast design calls for structures that can withstand 10,000 lbs. of TNT, then the designer will know that large trucks and vehicles will have to be kept to a farther distance because a single person cannot carry a 10,000 lb explosive.

Figure 17 Standoff distance to explosive yield comparison.

Source: FEMA 426

As mentioned early, the force of a blast wave diminishes over distance and time as the overpressure from the blast equalizes with the surround air pressure. Blast mitigation strategies first consider setbacks from certain site elements. The GSO established a setback of 100 feet for all its federal facilities. If a blast were to occur from outside the property where there is less control, the setback allows for more time for the blast wave to dissipate and have less of a force acting on the building. It is recommended that properties that cannot provide the proper setbacks to either a) relocate to a new location or b) build vertically. When building vertically, the lower levels of the building would be hardened and the more vital program space of the building would be located towards the upper levels further from the explosion, assuming the explosion is at ground level or below.

6.2 Effects on Architecture, Design, and People

There are four ways a person or building can be hurt or damaged in an explosion.[38] The first is the blast wave itself. The pressure behind the blast wave can rupture internal organs.   The second is through flying debris.   The blast wave will send debris flying in the air in fractions of a second. The debris can pierce a person causing injury or death. The third possibility is being thrown by the blast wave. Blast waves have enough force to throw a person in the air or against an object causing severe injuries to the person. The fourth possibility of injury is from secondary complications such as burns or crush injuries after the blast has subsided.

Of the four possibilities mentioned above, flying debris causes the most harm and injury to people. Glass debris is the number one cause of injury in explosions.[39] Glass can be a fragile and shatter from the smallest of explosions. A change in one

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[38] John M. Wightman and Sheri L. Gladish, *Explosions and Blast Injuries*, (Annal of (Emergency Medicine: Center for Disease Control, 2001), 664-678. https://www.cdc.gov/masstrauma/preparedness/primer.pdf.

[39] Ibid

psi is equivalent to 38 mph winds.[40] Blast waves from large explosions can shatter glass that is thousands of feet away from the point of an explosion causing extensive injuries to people and damages to buildings. Proper blast mitigation design strategies use high performance glazing and locate the glazing in strategic places that are further away from the initial blast location.

The repercussions of increasing safety measures include reducing the amount of glazing around the building. The result is a fortified buildings that becomes an eyesore to look at. However, technological advancements in window designs today can withstand larger loads before the window fails. Providing blast-resistant glazing to a building can be an expensive task and can use cause the project to go over budget. This is evident in the new U.S. Embassy in London as mentioned earlier.

Other building components can withstand larger overpressures and forces. The area of the building that will receive the most force is that which is perpendicular and closest to the point of explosion.[41] Initial design considerations to compensate for this effect are to change the building to a more convex shape or to articulate the building so that it is not perpendicular to any major areas that are exposed to explosions.

In the event of an attack, two factors can determine the success of a building. The first is how quickly the building is considered safe again to resume its day to day functions. The quicker the building recover from an incident, the more its security measures and building design can be concidered a success. The other determining factor on determining a building's success against a blast is its structural integrity. A building whose structure fails and collapses from a blast is considered to have failed and not be resilient against those forces. Some building are designed to do such a thing. Progressive collapse strategies utilize in building design so that the whole

[40] Explosive Shocks in Air. 1985

[41] Calculations of Blast Loads for Application to Structural Components. p32

building may not fail and collapse at once.[42] The purpose of a progressive collapse is to isolate the damage to a building and give more time for the building's occupants to escape during an emergency. This can be done by separating the building using large expansion joints so that only part of the structure may fail by the blast while a majority of the building's structure is able to withstand the blast.

The two case studies mentioned below are blast related incidents that changed the building code and designs for blast mitigation.

6.2.1 Oklahoma City Bombing

In 1995 a domestic terrorist attack occurred in Oklahoma City. The Alfred P. Murrah Federal Building was attacked by a truck filled with explosives. The explosion went off on the street only a few feet away from the federal building. The truck was remotely activated and the blast decimated half of the building killing over 150 people. The blast was large enough that it caused 650 million dollars' worth of damages to downtown Oklahoma City damaging buildings that were almost a mile away.[43]

Swift legislation came in an attempt to improve and secure federal buildings. Bombings and vehicle attacks began to be an important consideration during the design process. The federal building in Oklahoma City did not have a significant

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[42] General Services Administration, *Alternative Path Analysis & Design Guideline for Progressive Collapse Resistance*, 2013.

[43] Oklahoma Department of Civil Emergency Management, *After Action Report Alfred P. Murrah Federal Building Bombing*, (Oklahoma: Publications Clearinghouse of Oklahoma, 1995), https://www.ok.gov/OEM/documents/Bombing%20After%20Action%20Report.pdf

standoff distance to dissipate energy that was given off from the blast. Had the site design incorporated stronger site control and access, fewer people may have died. A memorial replaced the site of the federal building as a reminder of those who have lost their lives there.

6.2.2 U.S. Embassy Bombing 1998

A few years later in 1998, there was a series of planned attacks on U.S. Embassies in Africa. The embassies in Kenya and Tanzania we hit with deadly truck bombs that killed over 200 people, wounding more than 4,500.[44] These attacks were a turning point in the design of federal buildings. As a response to these attacks, the U.S. government published the SED program mentioned earlier and spent billions of dollars in design and construction costs to update a majority of it federal buildings overseas.

6.3 Risk Management

Planning and designing for blast mitigation means more time and money are needed for a project. A risk management studies help relieve some of those unforeseen expenses and prioritize safety concerns on site. Risk management helps the client and architect efficiently design a functional and safe working environment.

When planning against something like a terrorist attack, risk management must be defined. Risk management is the activity which seeks to understand potential risks and subsequently accept, mitigate, eliminate or transfer them to other areas in the building and site design. Risk management is made evident in Security and Site

[44] Rachel Briggs, Jennifer Cole, Margaret Gilmore, and Valentina Soria, *Anatomy of a Terrorist Attack What the Coroner's Inquests Revealed about the London Bombings,* (Royal United Services Institute for Defence and Security Studies, 2011) https://rusi.org/sites/default/files/201104_op_anatomy_of_a_terrorist_attack.pdf.

Design: A Landscape Architectural Approach to Analysis, Assessment and Design Implementation, Building Security - Handbook for Architectural Planning and Design, and GIS for Homeland Security. Assessing the client's needs against the amount of risk to the building and people prioritize safety in the project design. The client should use financial resources, consolidate operational needs, and specify institutional goals to determine security measures that should be taken into account for specific situations that may arise. This brings up essential performance criteria mentioned in a few sources. The National Capital Planning Commission (NCPC) and the General Service Administration (GSA) provide risk assessment models for designers to use. A general rule to determine proper security measures is that there are no general rules. Security and safety measures should be analyzed and incorporated into the building and site design specific to the buildings context and function.

Providing security measures is an expensive addition to project costs. The new U.S. Embassy in London cost over $1 billion.[45] That pricetag shows the extent to which the U.S. government is will to provide a safe built environment. As mentioned before, one of the main factors in determining the required safety measures is the standoff distance. Figure 18 shows the expected ratio between production costs of building and site components to standoff distances. The shorter the standoff distance, higher costs should be anticipated for hardening, building perimeter protection, and constructing bust structures. Providing a longer standoff distance is a safer design decision but does not mean it will reduce project costs. The larger the standoff distance means more land is required. Purchasing more land is more expensive and implies that there will be more perimeter costs to the project.

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[45] Sheena McKenzie, "A $1 billion glass cube: The embassy that Trump thinks is a 'bad deal'". (CNN, January 12. 2018)

Figure 18 Costs to standoff ratio of building components.

Source: GSA and Applied Research Associates[46]

Rather than a one-size-fits-all rule, future uniform guidelines provide a range of reasonable security and design responses for a variety of explosive threats. That is to say that a building will be best secured when designing for a specific threat. General safety is always paramount, but you cannot design a building that is 100% ‘terror’ proof, nor 100% ‘safe’ either.

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[46] *The Site Security Dsign Guide. 30*

6.3.1 Assets and Priorities

One of the most used risk assessments approaches is to understand the assets and priorities of the client and building. Again, this is added work to the project and can only be done upon the client s request, because the client will take on the financial burden of the extra safety measures designed for the project.

One of the first lines of defense for a building is how the site is accessed. This has been broken down in many ways, the most common being process that prioritizes different zones of the site and building. The National Crime Prevention Council (NCPC) is the government's planning agency for the nation's capital region and the GSA provides setting standards for the domestic site and building security guidelines. There are six general zones to the physical perimeter to enhance security measures. Zones 1 through 6 are label as follows: Building Interior, Building Perimeter, Building Yard, Sidewalk, Curb or Parking Area, and the Street. Zones 1-3 are presumed more semipublic while 4-6 are public spaces. The focus here will be in zones 1-3 as they are designed by the architect exclusively. Each zone has its security measures and responses. This is done through architecture, landscape, and streetscape responses that all focus on a specific asset to protect, in this case, a building. FEMA zones, however, are broken down into three areas; exterior perimeter, everything inside the site perimeter, and the building perimeter itself. Figure 19 GSA and FEMA site zoning for security.

Source: FEMA 426shows a chart that compares each of the different layers and zones of defense.

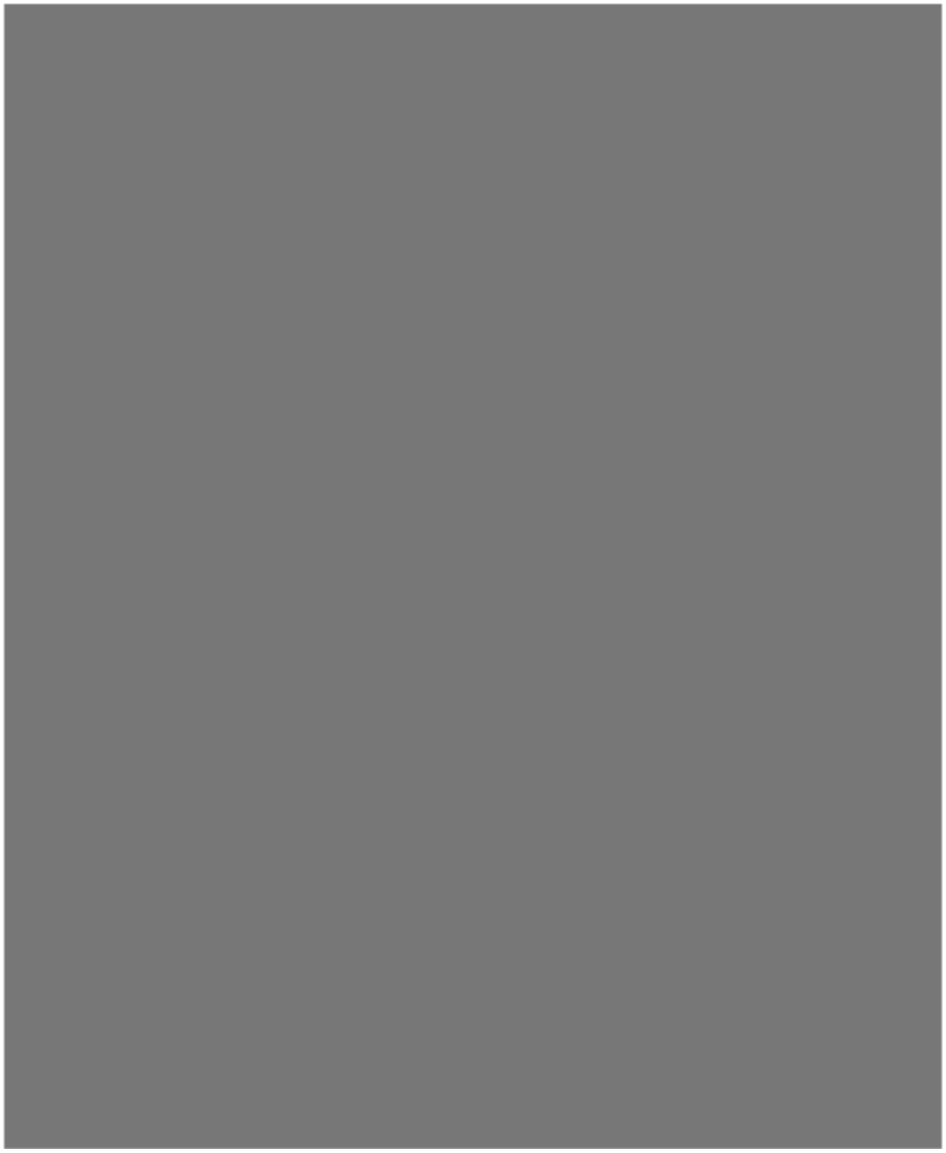

Figure 19 GSA and FEMA site zoning for security.

Source: FEMA 426

6.3.2 Swiss Cheese Model

The Swiss Cheese Model of System Accidents is a risk assessment and risk management tool for complex systems. The model was first detailed by James T. Reason and Dante Orlandella at the University of Manchester. The swiss cheese model was initially used for medical analysis but has expanded to other professions. The purpose of the model is to represent the various defensive layers or safeguards that have engineered and human involvement.[47] Different engineered applications and systems for a building include alarms, overrides, bollards, and fences. Human involvement includes those directly related to the procedures such as security personnel or staff. This system recognizes the holes or weaknesses in every layer of defense and compensates for those weaknesses using multiple layers of defense strategies. Figure 11 shows a conceptual layering of the swiss cheese model.

Figure 20 Diagram of the Swiss Cheese Model

Source: www.en.wikipedia.org

Each protective layer of a building is represented by a slice of swiss cheese, one behind the other. The holes in the slices represent the failures of the defensive layer. Using a flashlight as an example that represents a hazard to the system. If you shine the light on the slices of cheese, the light can only pass through the holes of the cheese. If the light goes through one slice but is stopped by the next, the system remains safe. An accident occurs when the holes in the slices align and the

[47] Human Error: Models and Management

light is able to shine through all the slices of cheese.   In its actuality, the holes in the slices of cheeses would constantly be moving around the slice and changing in size to represent the changes in flaws over time. [48]

The ideal system would be using a solid layer of cheese, an impenetrable protected system. As we know, that is not the case. The errors in a system can be categorized into two factors: active failures and latent conditions. Active factors are those that are related to human interference, or the human error.[49] This includes personal, drivers, and operators who might have a mistake or procedural violation. Active factors often affect the short-term outcome and are harder to identify and fix.

Latent conditions are failures that stay dormant for a while. These take on the form of technical faults or poor design decisions. The responsibility for these actions is given to the managers, designers, and builders. Latent conditions are easier to identify and apply the necessary remediation to solve the problem. Understanding potential latent conditions in the built environment is a way to have proactive design rather than reactive management.

An example of a 'swiss cheese model' is mentioned in the Guiding Principles of Design Excellence in Diplomatic Facilities. In the security guidelines, it is recommended that the facility utilize a three-tiered perimeter protection system. The first tier consists of a secure perimeter, typically using a perimeter wall and security posts to screen visitors and vehicles before entry. The second tier is the space just inside the perimeter. This space is void of any built obstructions to be

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[48] Thomas V. Perneger,. *The Swiss cheese model of safety incidents: are there holes in the metaphor?* (BMC Health Serv Res, 2005), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1298298/.

[49] Ibid

easily monitored. The third permitted is the building exterior which is suggested to be hardened for the protection of the occupants.[50]

6.4 Blast Resistant Design

Because interaction with the client/owner in a building project most often occurs through the architect/engineer— and it is often left to the architect/engineer to explain the design philosophy inherent in blast-resistant construction, its potential multi-hazard benefits, and cost tradeoffs. Architects/engineers have a critical role to play in the practical diffusion of new knowledge and approaches for blast-effects mitigation.[51]

The closer the building is to the location of the exposition, the more force will be put on the building. Vehicles can carry much heavier loads than a single person and can pose a large threat to a building. The explosive damage that can be done through the use of a vehicle can be devastating. Blast mitigation strategies should look to control the use of vehicles. If the site is too small or narrow and a proper offset cannot be met, the next option should be to raise the building or portions of it up and away from the location of an explosion.

Our conventional approach to blast design is similar to that for seismic design, in two ways: (1) both loadings clearly are dynamic and, hence, solutions are energy-based, and (2) the way we detail structural elements determines the effective loads for

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[50] *Guiding Principles of Design Excellence in Diplomatic Facilities*, 89.

[51] National Research Council (U.S.). Committee for Oversight and Assessment of Blast-effects and Related Research,. *Protecting people and buildings from terrorism : technology transfer for blast-effects mitigation.* (Washignton, D.C.: National Academy Press, 2001)

which structures must be designed (meaning, we limit the strength we need to supply by allowing post-elastic behavior to dissipate energy).[52]

[52] Donald O. Dusenberry, *Handbook for blast-resistant design of buildings* (Hoboken, NJ: Wiley & Sons, 2010)

Chapter 7: Enduring Democracy, Future Embassy Scenario

The application of the preferred future is applied to an embassy typology with a focus on building material, technology, site access, and occupational health projected in 50 years. These drivers are analyzed and are manifested throughout the site. The purpose of this project is to apply the preferred futures approach to an embassy design that is driven by life safety. The goal is to identify possible emerging issues in life safety and design an architectural response those issues.

7.1 The Future of a U.S. Embassy in Jerusalem:

The study for a new embassy in Jerusalem is an ideal setting for the applying a preferred futures approach. An embassy in Jerusalem will require a specific focus on life safety in its design no matter the outcome of the current geopolitical conflicts. The design, along with new technologies, should work in unison to provide a safe working environment. The design should be open and accessible to all types of public access and reflect a strong relationship between the U.S. and Israel.

The permanence of the embassy is represented differently across cultures. As an example, some Japanese buildings are routinely deconstructed and constructed again using the same materials and construction process. This short-term building culture is viewed as keeping the building young and new. However, typical in American culture, buildings are constructed to have longer life spans and are designed to endure changes over time. The embassy in this project will be to anticipate possible changes in the life safety design drivers and withstand those changes over time.

7.2 Preferred Future 50 Year Growth Scenario

The built environment will be a safer environment in the future. Building performance will improve and building systems will become more durable adding to the reliability of the building.

Building systems such as mobile, self-healing facades will adapt to the current weather optimizing building performance. The use of 3d printers will speed up the building construction process. These printers will also benefit the construction of temporary structures. New buildings materials will become more resilient, like carbon-fiber enhanced woods or synthetic construction silk. Other materials will become less used as some natural resources have depleted. The design of buildings will be able to take on new forms and shapes that are currently impossible.

Real-time digital technologies will help promote awareness of potential harms to the building. The incorporation of AI and VR in architecture will improve current life safety and security measures. As an example, fire alarms will no longer just tell you when there is a fire but the system will provide real-time information guiding the occupant to the safest path of egress. This can be done with a combination of sensors and displays that work in unison. Wireless technologies will look to optimize performance on a block scale rather solely on building scale. This means that buildings will be actively responding to the surrounding building environment. AI and VR technologies will be much more evolved and used in day to day situations. This could imply that there may be more people who can work from a remote locations with the assistance of these technologies at a mobile workplace. This means a smaller building footprint would be required for full-time staff.

Computer chips and data chips are becoming smaller and quicker at performing their functions. The same can be said for security technologies incorporated in building design. The sensors and computers at security checkpoints will be able to detect hazardous materials, smells, and even your heart rate. These types of systems will be able to help mitigate the human error in maintaining a building. Nano chips will be used mixed in with the construction of the building. These smart ships can be infused with various elements of the building. As an example, these chips can be fused in with critical structural members and can relay information back to a central database to alert the occupants if the structural member is failing or needs repairs when damaged.

Public transportation will become more accessible with the integration of shared transportation programs. More people will use a vehicle share program or a public form of transportation if needed. Others will utilize a more ecofriendly option like bike shares which will become more used and accepted as demand for fossil fuels decreases. Automobiles will become fully electric by this time and would require charging stations or charging platforms at their parking space.

The use of personal aviation will be anticipated for this design. The drones will be used to deliver mail and even people over shorter distances. This brings a new design issues to site access. Rather than designing a facility that prohibits this form of transportation, the building design should anticipate the use of personal aviation vehicles.

Governance has been a design driver when constructing an embassy. The U.S. – Israel – Palestinian relation has been less hostile than in previous years. This is due to Israel's recognition of Palestine's people in the West Bank. Israel has opened its infrastructure to the Palestine people. Roads, buildings, and public areas in Israel are used by more people of the West Bank as compared to the segregation of the Palestinians 50 years ago. The new embassy in Jerusalem would be ideal to help serve both Israeli and Palestinian peoples. Although these new policies are an attempt to mend the relationship between Israel and the rest of the Middle Eastern countries, acts of extremism still occur. The U.S. relations with Israel is still seen as hostile with the goal for the U.S. to be a global leader by some as extremists group. Life safety measures in foreign U.S. properties remains a vital design driver. With prior investments in overseas buildings, the U.S. will pay top dollar in designing a new embassy in Jerusalem.

7.3 Omissions

It should be noted that preferred future designs are speculative in hopes that these future innovations and drivers may become considerations in the design process. Embassy design and specific programming information are considered confidential. This design takes into concertation the information that is withheld from the general public on specific embassy design requirements.

7.4 Project Explorations

The goal of this project is to explore design possibilities through the preferred futures method. The goal of this design is to suggest how we might engage an embassy in the future while providing proper safety measures to its occupants and users. The following aspects were explored in the design.

- Erasing the perimeter edge. The design should not have a strong visual separation from its immediate surroundings. Allowing for a transition space will make the design more approachable. This would be reflected in the existing relationship between Israel and U.S. countries. Perimeter hardening should be used only were needed in areas that require stricter security measures.
- Building mass that is responsive to surrounding context. The building mass shall not be overpowering to its site or surround context. History has shown that U.S. government buildings pose as potential targets at times. Given the

close proximity to other Middle Eastern countries and the poor U.S. relations with them, the building should situate itself with its surrounding context as to not stand apart from its environment.

- Decentralized security checkpoints. The design should allow for multiple access routes for pedestrians. This will make the site more accessible and to open to the public. Previous attempts on embassy design have limited access to its users through hardened perimeters. This closed the embassies off from the public physically and visually. The development of advanced support technologies will help with monitoring and detecting threats throughout the site. The use of 3D printers can build durable and portable security screening areas around the site.
- Control access for multiple forms of public and private transportation. This design shall allow access to bicycles, cars, and personal aircraft vehicles. The future of transportation will be through 'shared' programs such as car shares and bike shares. The site design should provide an area on site for limited public vehicle access. The site should also respond to the public transportation routes in the design to accommodate the users of public transportation.

7.5 Site Selection:

The project site is in North Talpiyot region of Jerusalem. It is one mile north of the current U.S. Consulate in Jerusalem and three miles from the American Cultural Center, a prominent outreach program through the U.S. Embassy. It consists of two blocks; one that is currently owned by the U.S. at about 8 acres, and an adjacent lot which is just over 5 acres.[53] Both lots are generally flat and undeveloped. There is a street that runs between the two blocks. Figure 21 shows the site and a 100-foot building setback.

[53] Where would a U.S. Embassy in Jerusalem actually go?. Adam Taylor. 2017

Figure 21 Current site with the 100-foot setback.

Source: Google

The site sites between a major freeway to the west and a four-lane artery road along the south. There is public transportation stops on both roads along the site. Adjacent to the north of the site is a small public park. To the east and west are medium-rise apartment buildings. There is a business complex, a geriatric hospital, and a school to the south. Figure 22 shows the land use in this area.

Figure 22 Land use around the site.

Source: Author

7.6 Program Space

The programs that were considered for this project included the space from the current U.S. Embassy in Tel Aviv. These programs and agencies included:

- The Department of State
- The Department of Agriculture
- The Department of Commerce
- The Department of Defense
- The Department of Justice
- The Department of Homeland Security

Additional spaces included:

- an art gallery

- cafeteria
- a library
- security checkpoints

Spatial requirements were assumed by previous embassy reports and assumptions in the preferred future narrative. The total space required calculated to under 400,000 square feet. The program adjacency diagram used in this design are shown in Figure 23 and Figure 24**.** The darker colors represent high security areas and the lighter colors represent areas that require less security measures. Agencies were grouped based on the department's security needs and business interactions.

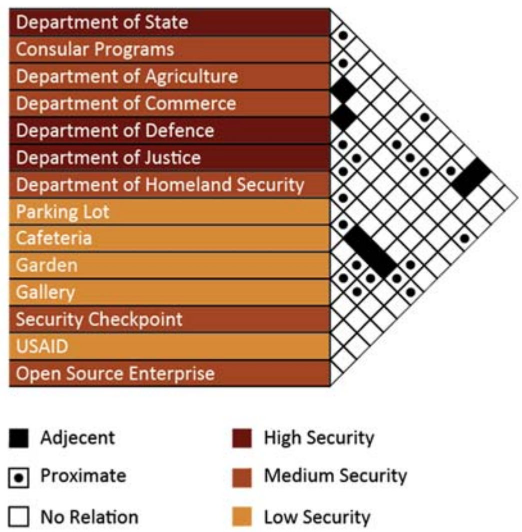

Figure 23 Adjacency diagram of major agencies.

Source: Author

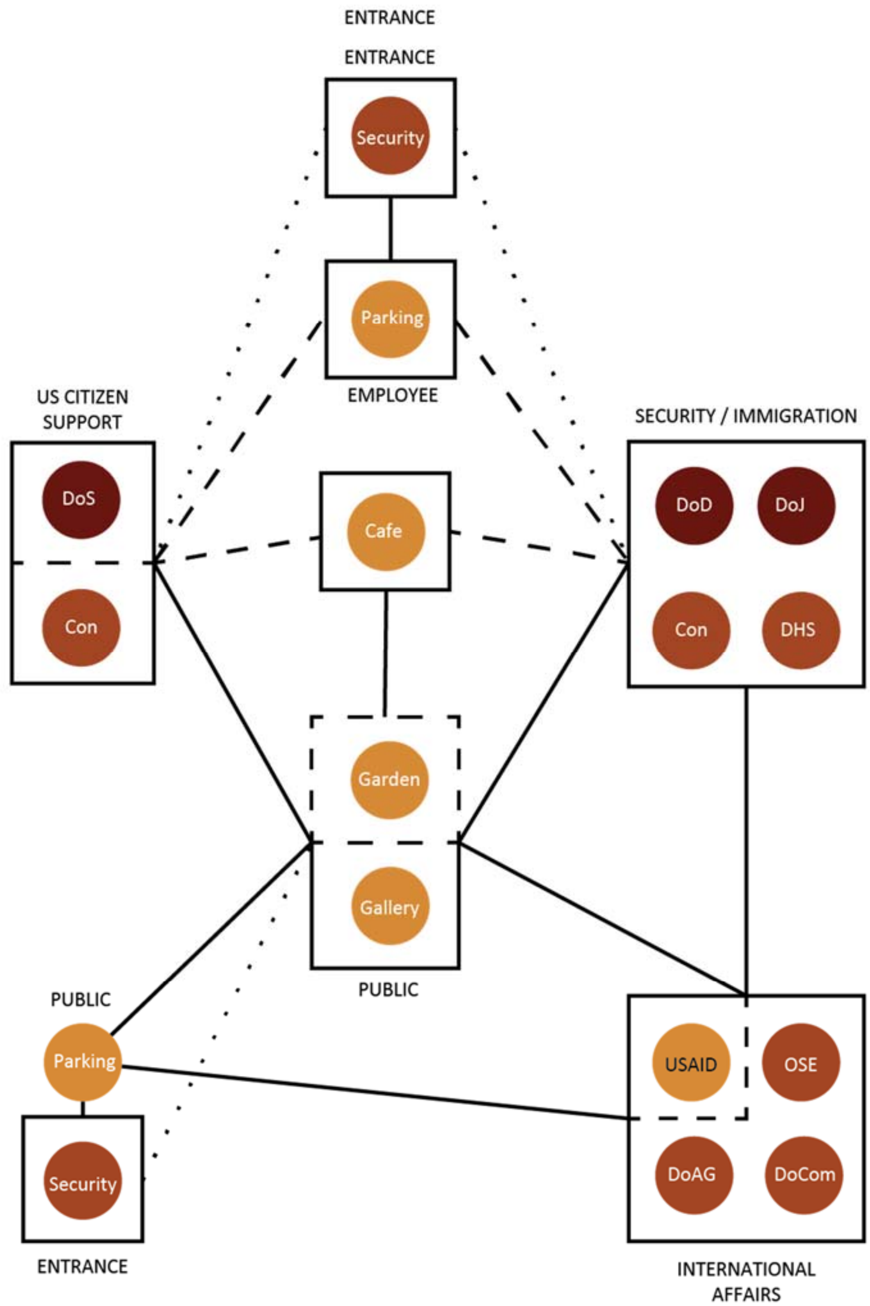

Figure 24 Building clusters and adjacency.

Source: Author

7.7 Site Plan

The design for this embassy typology separates building programs based into the two separate blocks. Parts of each block are raised above ground level on a podium surrounded by landscape and water features. The buildings on the west block allow more access to the public. At the ground level under the platform of the west block are the public spaces such as the gallery and library. The area under the podium in the east block is used for employee parking. At the podium level of each block are the entrances to the buildings. The podium on the west block is setback from the street. This is comply with the setback requirements and allow for limited onsite parking for public use. The podium on the east block is a hardened barrier. This was in response to its proximity to the street.

The entrances to the ground and podium levels are designed to allow for passive prescreening areas. Each building would have a security screening area attached to the outside of the building. This type of screening process allows for the building and site design to be more welcoming to its users. The placement of the security checkpoints on site are located in a places that visitors are required to pass through before entering any building. Figure 25 is the site plan shown below. Figure 26 and Figure 27 show perspectives of the design in its surrounding context.

Figure 25 Site plan.

Source: Author.

Figure 26 Perspective of the west lot.

Source: Author

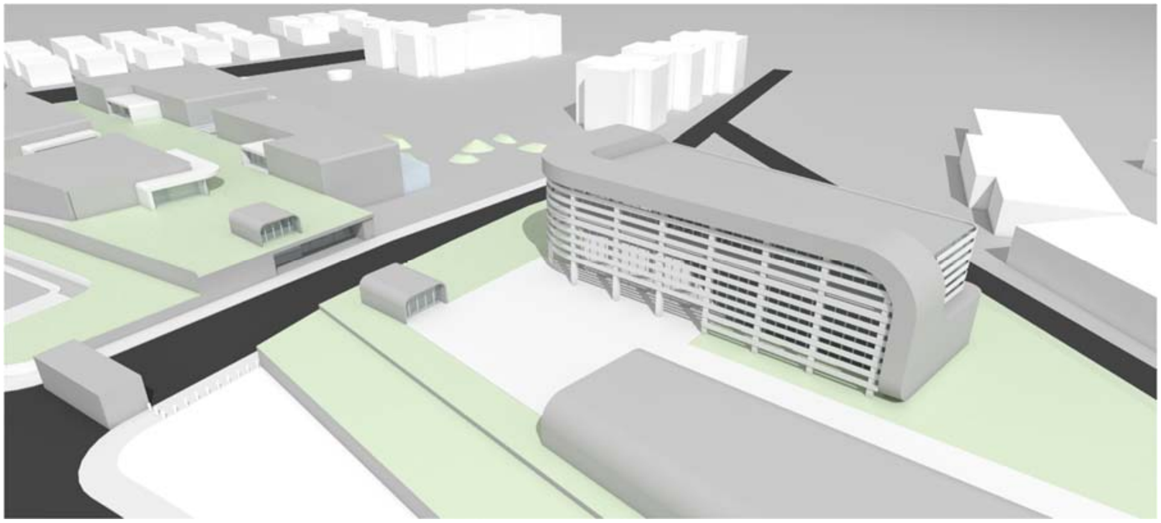

Figure 27 Perspective of the embassy building on the east lot.

Source: Author.

Organization of these spaces utilized the two blocks on site while keeping the use of the road that bisected the site. The west block is located closer to the public areas such as the commercial businesses to the south and the small park adjacent to the north. The program spaces that have less security requirements and those with public access would be located on this block. This is also closer to the public transportation routes and primary pedestrian access to the site is located along the primary roadways that are adjacent to the site in the west and south.

The east block would be used primarily for the embassy building. This block would require more safety requirements. The street in the middle of the sire will be used primarily by pedestrians and employee vehicles that are parking on site in the east block. Parking for employees would be provided in a secure lot under the embassy building. Public parking is limited and located on the south side of the site which can also work as a drop off area. Figure 28 shows the ways to access the site by vehicles and pedestrians.

Figure 28 Site plan showing how to access the site.

Source: Author.

7.8 Analysis of Design

The entrances to the buildings and podiums are open to the public. The pathways incorporate elements of nature such as vegetation and water features which provide a softer design rather than using fortified walls as seen in Figure 29 and Figure 30. The pedestrian entrances to the site are either winding paths or extended ramps that incorporate passive security screening systems. These technologies would be designed to blend in with the building. As an example, they can resemble different vegetation and be unseen by the pedestrian as they walk by. A threat would be detected by the time it had reach any building entrance.

Figure 29 Main pedestrian entrance from the west.

Source: Author

Figure 30 North entrance has a winding ramp that leads up to the podium.

Source: Author.

Other technologies such as smart glass are used throughout the site. mart glass is both an interactive display and warning system that is synced with other digital technologies on site. The smart glass that can assist a pedestrian in locating where to go from their meeting. If needed a visual display of an operator can also be projected on the screen to help assist the pedestrian. Figure 31 shows an example of how the smart glass technologies respond to evening and closing times. The system would use lights to illuminate the area around it as well as display any important information for the occupants such as building closings or any immediate means of egress.

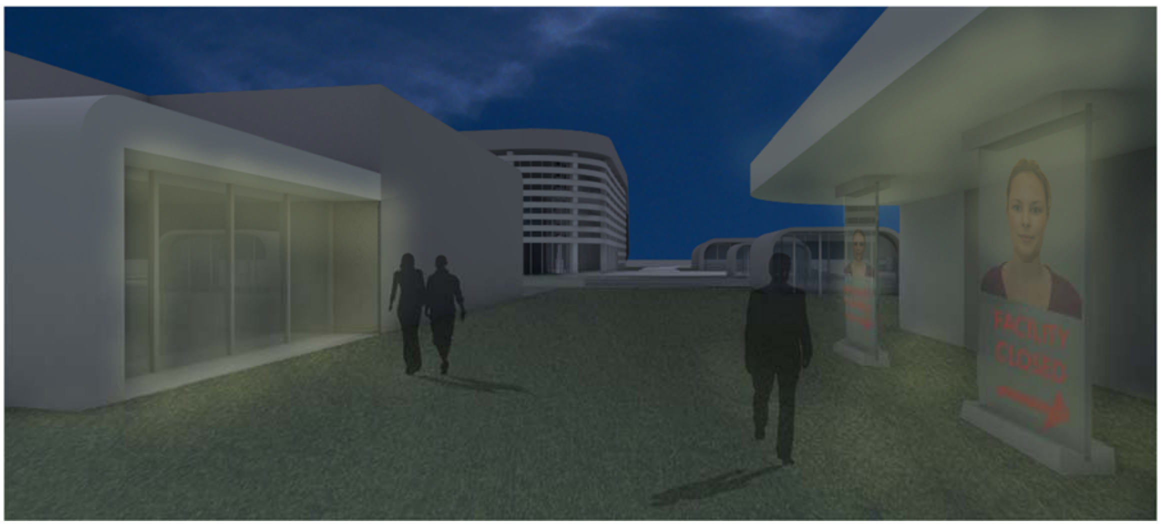

Figure 31 View from the podium at night facing the embassy.

Source: Author.

The highest priority for security on site is the embassy building. Figure 32 shows the public access to the embassy via a circulation tower which provides the prescreen security check before entering the embassy.

Figure 32 A view of the embassy and circulation tower.

Source: Author.

The balcony space in the embassy building provides a space in the building that is secure while providing a connection to the outdoors. The balcony wraps around the building and is protected by reinforced horizontal members that restrict the view from the outside, provide shading, and it acts as a defensive barrier against potential blast effects. Figure 33 shows a view from the balcony.

Figure 33 Perspective from the balcony in the embassy building.

Source: Author.

The other access to the embassy would be via the landing pad. As mentioned earlier, the pathway that leads to the embassy buildings incorporates security screening technologies that process and analyze pedestrians as they walk down the path. Personal on-site would be notified of any potential threats by the time the pedestrian reached the building. Figure 34 is a perspective from the pathway leading to the landing pad looking at the embassy. The embassy building is not visually overbearing on the site or in its context. The unique wrapping of its outer structure acts as a perimeter hardening feature against potential blasts while distancing itself from the anticipated location of the blast. This is strategically located at the bottom of the building and sides closest to the street.

Figure 34 View from the landing pad.

Source: Author.

7.9 Reflection on the Design Outcome

The site addresses these potential safety issues:

- Site access by providing limited and regulated access for car share public parking. Placing the entrance close to public transportation stops gives pedestrians direct access to the site.
- The site provides a safe and isolated area for personal aircraft.
- Open access for pedestrians via long or winding pathways with unrestricted visual access.

- Support technologies located at a pedestrian checkpoint at building entrances. Specifically at street level.
- AI and digital sensors throughout the site help identify potential threats and identify proper egress routes. This is done by elevating the site to account for longer pathways and screening areas.
- High performance concrete and smart glass are used in context with compact earth and water elements with the site.
- Integration of natural elements and views incorporated in the site. Natural daylighting to space underground and natural vegetation within the building communal spaces.

The buildings on site address these safety issues:

- All the buildings in this design elevated which increases the setback distance. In the incident of an explosion, the extended setback would help weaken the shock wave before it hits the buildings.
- The elevated building perimeter can be reinforced using anti-ram barriers were provided. This would help against vehicles or other collisions into the building.
- All buildings have a detached security checkpoint. The purpose of this design is to isolate and control anything that should not be entering the building.
- The embassy building in this design has detached horizontal shading members. They are attached to part of the exterior structure. The horizontal members also work as a defense barrier against blasts that are in close proximity to the building.
- The building has an overall balance of openness and structure visually. This provides areas with more line of sight and visual access while also being enclosed in a safe environment.
- On the north side of the embassy, the wrapping around the building is low and runs along the bottom of the building. This can be used as a hardening structure for the building that also acts as an aesthetic feature.

This design only addresses some of the potential life safety issues that may arise in the future. Further research should compare the different design responses to the four futures. The each will have different design outcomes that provide innovative design solutions to the various life safety issues. The designs do not need to be good or bad but must reflect the future narratives.

Chapter 8: Conclusion

Life safety is and will always be linked to building design. No building is impervious to all potential harms and hazards. Building and site security is an ongoing discussion that needs to be revisited from time to time. How can the designers of a project driven by life safety anticipate future changes, so the design outcome is more resilient and adaptive over time? The preferred future approach to life safety design anticipates potential problems that can pose a risk in compromising the safety of the occupants. By speculating on the possible futures, the designer is given the opportunity to create innovative approaches to performance based designs. This thesis looked at how people access the site, lack of integration of new technologies into the design, and the value of occupant well-being in relation to building safety.

Building design alone cannot guarantee the safety precautions for a project. Continuous vigilance and data assessment such as occupancy use should always be analyzed through the lifespan of the building. This includes active security measures such as on-site personnel as well as issues in building codes. The preferred future design approach can effectively deal with potential safety issues in the future. The approach to embassy design today does not adequately deal with the safety codes of tomorrow. This is one of the reasons why embassy buildings often are not up to safety standards and require expensive renovations at the tax payer’s expense.

The design of this thesis is meant to be used as a speculative design approach. The preferred future approach allows designers to speculate future uses of buildings within its context in hopes that the future design transcends modern culture and develops into new norm which will accept and anticipate future changes. This can shorten the lag or even break the cycle of architecture as a response to life safety as mentioned in the earlier chapters.

The embassy typology in this design is a product of the future scenario narrative in Chapter 7. The design would be different had another scenario and narrative been chosen. The design of this embassy typology is different than those that were mentioned earlier in thesis. This new block-podium embassy has the potential ability to adapt to changes in the future. The embassy facilitates will have a longer life span and be able to adapt to the changing life safety needs. Current embassy typologies are unable to accomplish this because the design drivers focus on life safety issues today.

Using the preferred future approach to safety design allows the designer to focus on emerging issues that can be addressed architecturally. Rather than having life safety concerns constrain the project, there is an opportunity for design innovation through this approach. Innovation can be achieved in architecture through the incorporation of technology, performative design opportunities, and collaboration between working disciplines.

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