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SOFT TARGET SECURITY: ENVIRONMENTAL DESIGN AND THE DETERRENCE OF TERRORIST ATTACKS ON SOFT TARGETS IN AVIATION TRANSPORTATION

by

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Recent attacks on airports exposed an emerging threat to the security of the traveling public, attacks on soft targets. Incidents throughout the world indicate that terrorists, seeking to maximize life loss, and economic and symbolic destruction, have changed their focus to soft targets. The thesis examines plausible deterrence measures through environmental design for crowd protection in the aviation transportation sector. The policies of the United Kingdom, Belgium, and the United States Department of Homeland Security, Transportation Security Administration (TSA), are compared to extract best practices for soft target security. Using case analysis of terror attacks on airports in Brussels (2016), Los Angeles (2013), and Glasgow (2007), operational space, deterrence, infrastructure design, and human perception are explored as a means to reduce risk. The thesis finds that new airport environmental design strategies are required to protect crowds, harden the infrastructure, and build resilient structures. The thesis recommends applying environmental design countermeasures in the typically crowded areas of airline ticketing queues, TSA passenger security checkpoints, and baggage areas by changing the adversaries' perception of opportunistic targets. New risk-assessment models, changes to physical structures, use of new technology including robotics, and the broader use of simulation models are identified as required paths to improve the effective security of soft targets in airports.

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SOFT TARGET SECURITY: ENVIRONMENTAL DESIGN AND THE DETERRENCE OF TERRORIST ATTACKS ON SOFT TARGETS IN AVIATION TRANSPORTATION

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ABSTRACT

Recent attacks on airports exposed an emerging threat to the security of the traveling public, attacks on soft targets. Incidents throughout the world indicate that terrorists, seeking to maximize life loss, and economic and symbolic destruction, have changed their focus to soft targets. The thesis examines plausible deterrence measures through environmental design for crowd protection in the aviation transportation sector. The policies of the United Kingdom, Belgium, and the United States Department of Homeland Security, Transportation Security Administration (TSA), are compared to extract best practices for soft target security. Using case analysis of terror attacks on airports in Brussels (2016), Los Angeles (2013), and Glasgow (2007), operational space, deterrence, infrastructure design, and human perception are explored as a means to reduce risk. The thesis finds that new airport environmental design strategies are required to protect crowds, harden the infrastructure, and build resilient structures. The thesis recommends applying environmental design countermeasures in the typically crowded areas of airline ticketing queues, TSA passenger security checkpoints, and baggage areas by changing the adversaries' perception of opportunistic targets. New risk-assessment models, changes to physical structures, use of new technology including robotics, and the broader use of simulation models are identified as required paths to improve the effective security of soft targets in airports.

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LIST OF ACRONYMS AND ABBREVIATIONS

ACI	Airports Council International
ANPR	automatic number plate recognizer
AOA	air operations area
AOR	area of operation
ASAID	aviation security in airport development
ASC	airport security coordinator
ASIS	American Society of Industrial Security
ASP	airport security program
ATA	Air Transport Association
ATRiM	antiterror risk infrastructure protection model
ATSA	Aviation Transportation Security Act
BASP	Belgian Aviation Safety Programme
BCAA	Belgian Civil Aviation Authority
CCTV	closed circuit television
CFR	Code of Federal Regulations
CIA	Central Intelligence Agency
CMT	Crisis Management Team
CONTEST	Countering Terrorism
CBP	Customs and Border Protection
CPNI	Centre for the Protection of National Infrastructure
CPTED	crime prevention through environmental design
DfT	Department for Transport
DHS	Department of Homeland Security
EASP	European Aviation Safety Program
EDCH	explosive detection canine handler
EC	European Commission
EU	European Union
EXIS	Exercise Information System
FAA	Federal Aviation Administration
FAM	federal air marshal

FBI	Federal Bureau of Investigation
FFDO	federal flight deck officer
FSD	federal security director
GDP	gross domestic product
GLA	Glasgow International Airport
HSPD	homeland security presidential directive
I-STEP	Intermodal Security Training and Exercise Program
ICAO	International Civil Aviation Organization
ICP	incident command post
IED	improvised explosive device
IEM	integrated emergency management
IP	infrastructure protection
IRA	Irish Republican Army
ISIS	Islamic State in Syria
KSOC	Knightscope Security Operations Center
LAFD	Los Angeles Fire Department
LAPD	Los Angeles Police Department
LAWA	Los Angeles World Airports
LAX	Los Angeles International
MATRA	Multi-Agency Threat and Risk Assessment
MOU	memorandum of agreement
NaCTSO	National Counter Terrorism Security Office
NASA	National Aeronautics and Space Administration
NASP	national aviation security programme
NIPP	National Infrastructure Protection Plan
PAS	Publicly Available Specification
PBE	performance based engineering
pph	passengers per hour
RAG	Risk Advisory Group
RAM	random action measure
RBS	risk based security
RFID	radio frequency identification

RMAT	Risk Management Tool
SEG	Security Executive Group
SIDA	security identification display area
STS	soft target security
TATP	triacetone triperoxide
TBIT	Tom Bradley International Terminal
TRANSEC	Transport Security and Contingencies Directorate
TSA	Transportation Security Administration
TSO	transportation security officer
TVA	threat and vulnerability assessments
UIA	urban innovative actions
VBIED	vehicle borne improvised explosive device
VIPER	visible intermodal prevention and response

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EXECUTIVE SUMMARY

Terrorist attacks on soft targets at airports have increased in the last decade. The events of September 11, 2001, exposed deep vulnerabilities in the security of the aviation sector. As a result, the U.S. government enacted concrete policies and procedures to prevent future airline hijackings and to deter prohibited items from entering aircraft. However, since 2011, 14 airport attacks have occurred worldwide.[1] The increase in attacks at airports demonstrates that adversaries are continuously seeking new targets in the aviation sector. At the same time, a general increase in air travel has led to larger crowds at airports. An attack on soft targets in the airport environment could cause a significant disruption of the aviation industry, leading to a large negative effect on the U.S. economy, not to mention the social and psychological health of this nation's citizens.

An examination of several airports reveals that ticket counters, baggage claim areas, and screening checkpoint queues are easily accessible to adversaries seeking to harm this country. Such areas are open to the general public, including nefarious actors engaged in pre-surveillance to establish a plan of attack. Presently, people have minimal physical protection in these publicly accessible areas. Furthermore, the United States does not have a systematic national policy approach in place for airport soft target security (STS). The purpose of this thesis is to explore how policy approaches and environmental design countermeasures can be applied to the problem of soft target protection in airports. The overarching goal is to mitigate the threat to crowds, minimize the impact of an attack, and disrupt the terrorist planning process.

The recent increase of airport attacks across the globe and the limited literature for explicitly protecting crowds in the airport environment provide the impetus for this research. The Aviation and Transportation Security Act (ATSA) does not specifically mandate the protection of public spaces within the airport environment. The death of 32

[1] "Recent Airport Attacks at a Glance," Associated Press, June 29, 2016, https://apnews.com/4950118bb7e944c6b3bc8045b39bd24e. This article does not include the Florida Fort Lauderdale active shooter event on January 6, 2017.

civilians during the terrorist attack at Brussels International Airport, for example, illustrates the vulnerability of crowds in these spaces. However, empirical research in the criminology field, such as crime prevention through environmental design (CPTED), offers proven methods that may be transferred to the airport construct. Based on this framework, this research explores methods of deterring adversaries, disrupting the terrorist planning cycle, and prescribing proven environmental counter-measures to mitigate an attack on soft targets in airports.

The research design and solution included three case studies of terrorist attacks on soft targets in airports: Brussels in 2017, Los Angeles in 2013, and Glasgow in 2007. These cases were chosen because they were deliberate attacks on soft targets in airports. The Brussels case involved the use of improvised explosive devices (IEDs) hidden in luggage and detonated by terrorists in the interior public terminal. The Los Angeles case involved the use of an assault rifle by an active shooter on both the non-sterile and sterile area, and the Glasgow case involved the use of vehicle-borne improvised explosive devices (VBIEDs) to attack a public terminal.

Human perception of target selection, airport configuration, attack consequences on security, the economy, and implications of airport design were analyzed. The data sources derived from literature, agency reports, airport records, and configuration diagrams. The analysis criteria included airport terminal layouts, infrastructure materials, and event documentation. The mode of analysis included attack location, method, and impact. The independent variable was the airport environmental design and the dependent variable was human attack perception. The United States and European Union (EU) soft target counter-terrorism strategies were also compared and analyzed.

Aviation transportation is critical to the lives of Americans and the global economy. Aviation alone accounts for more than 5% of U.S. gross domestic product (GDP), contributing over $1.6 trillion to the total market economy.[2] An airport attack

[2] Federal Aviation Administration, *The Economic Impact of Civil Aviation on the U.S. Economy* (Washington, DC: Federal Aviation Administration, 2016), https://www.faa.gov/air_traffic/publications/media/2016-economic-impact-report_FINAL.pdf.

could result in a loss of $17 billion in GDP from lost air travel.[3] As demonstrated by the case studies, airport attacks disrupt the aviation system network and cause cascading effects. The attacks cost airports and airlines millions of dollars in lost airline revenues, business continuity operations, emergency response, infrastructure damage/renovation, crowd management, injuries, and deaths. The attacks also impact both the local and national economy. In Brussels, for example, the attack cost the Belgian economy an estimated 4 billion euros.[4] To evolve with the emerging threat, a national systematic approach is needed to address the protection of crowds in the airport environment.

In the case of Brussels, where terrorists used improvised explosives, the materials used throughout the interior directly added to the human casualty rate. People were injured by building debris, glass windows, and interior ceiling panels fragmented by the explosives' shock wave. In the Glasgow case, the terrorist's attempt to detonate the explosives by setting a fire resulted in damage to the exterior and interior building that caused extensive smoke in the interior building, and water damage from automatic sprinkler systems. In Los Angeles, the spontaneous evacuation of more than 4,500 people, the confinement of an additional 20,000 people in the terminals, and the impact to 1,500 flights, resulted in a significant disruption of airport operations.

This research revealed that alternative methods for airport environmental design exist and can be used effectively to mitigate risk. Airport authorities and government officials made some significant changes to protect soft targets and improved airport infrastructure in the aftermath of the attacks. For example, at Brussels and Glasgow airports, passenger pick-up and drop-off zones were moved outside the perimeter of the terminal building. Additionally, blast mitigation materials replaced glass fixtures. Turnstiles have been added to the entrance of security screening checkpoints and baggage claim areas as extra layers of access control security. Additionally, at Glasgow airport, 300 steel bollards and automatic number plate recognizers (ANPR) were installed. Los

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[3] Emily Gersema, "Attack on an Airline or Airport Could Cost the Economy Billions in Losses," *USC News*, paragraphs 8, 9, February 9, 2017, https://news.usc.edu/116174/attack-on-an-airline-or-airport-could-cost-the-economy-billions-in-losses/.

[4] Damien Sharkov, "Brussels Attacks to Cost Belgium $4.47 Billion," *Newsweek*, March 23, 2016, http://www.newsweek.com/brussels-attacks-cost-belgium-4-billion-euros-440013.

Angeles airport is continuing to develop environmental counter-measures, and plans are underway to add security desks in the public terminal areas.

This thesis makes several recommendations to implement airport environmental counter-measures that will improve STS, specifically in airline ticketing queues, screening checkpoint queues, and baggage claim areas. These spaces are critical pinch-points that concentrate soft targets into high-density targets of opportunity. The recommendations include applying the CPTED principles of defensible space (territoriality, surveillance, maintenance, and access control) by using the design concepts of organized, mechanical, and natural features. These concepts include altering the adversaries' human reactional elements and perception of targets. Modifying temperature, pressure, lighting, sound, and creating optical illusions can achieve these measures. Placing camouflage elements, such as fabric netting, mirrors, indoor planters, and water features, provide deterrence and deception in perception capabilities of crowds. Additionally, adding sound absorbing materials decreases the noise level and makes the crowd appear smaller while simultaneously calming the users of the space.

In the airline ticketing area, crowd congestion can be minimized and distributed by increasing the use of technology. For example, technology developed to have passenger pre-pay for weighing and checking in luggage (pre-airport arrival) can significantly decrease airline check-in queues. Establishing multiple drop-off zones for luggage dispersed throughout the airport grounds further reduces crowd formations. Additionally, bomb-sniffing canines should be actively utilized in these areas to detect explosives and provide a deterrence effect. Shrapnel and fragmentation resistant materials should be utilized throughout these areas to mitigate the risk from IED explosions.

In the screening checkpoint queue, distributed versus centralized queue concepts offer enhanced threat reduction at minimal cost. Distributed queuing also decreases the number of individuals per square foot, which makes the crowd appear smaller. Blocking the view of the queuing line with large planters, artwork panels, or frosted blast-resistant glass can further deter the adversary from conducting pre-surveillance or seeing the "big picture." Additionally, the use of lighting, such as in theater production, can alter the perception of the line.

Similar features can also be integrated in the baggage claim areas to obstruct the view of attackers and provide mitigation elements to protect people. In the event of an IED explosion or active shooter, these materials can improve shock and projectile absorption. The placement of closed circuit televisions (CCTVs), explosive-detection canines, and additional police patrols in these areas add additional layers of security. Lastly, placing the baggage claim in an inaccessible area to the public, or installing turnstiles to limit access, decreases the risk of opportunistic attacks.

This thesis also recommends the utilization of risk assessment models, physical structures and technology, robotics, and simulation models to evaluate and enhance security measures properly in the non-sterile airport domain. Independent risk assessment groups, such as the UK's model of the Risk Advisory Group (RAG) and Security Executive Group (SEG), can provide subject-matter expertise to assess attack methodology through a game theory model. The deliberative method for ranking risks is also a great tool to calculate the number of lives lost per event. Physical blast-resistant technology, such as Kalwall windowpanes, offer effective alternatives for airport glass re-placement because they are shatterproof, fire-retardant, lightweight, and aesthetically appealing. Portable bulletproof and blast-resistant curtains, such as origami Kevlar shields, deliver an adaptable method to the evolving threat and are flexible, lightweight, and can be transported. Robots, such as Knightscope, offer the ability to augment physical security techniques because they have advanced detection sensors, such as audio and visual recognition, thermal imaging, license plate recognition, weapon detection, emergency alert alarms, and can transmit pre-recorded announcements, which are effective for crowd management. Computerized simulation models provide a great alternative to attack scenario planning and minimize costs needed to assess and implement physical security counter-measures. The Multi-Agent System, for example, is effectively used for emergency management and evacuation simulations. The Anti-Terror Risk Infrastructure Protection Model (ATRiM) also offers an analysis of operational and physical risk vulnerabilities in infrastructure.

Policies, such as UK's Countering Terrorism (CONTEST), which place crowd protection in the fore of government planning and risk mitigation strategies, offer best

practices to emulate. In the United States, the Transportation Security Administration has made significant strides in risk-based security. Over the years, it has updated policies to detect and deter threats, deployed explosive detection canine handlers and visible intermodal prevention and response teams, and liaised with the international aviation community to enhance aviation transportation security. Ultimately, however, it is up to airport operators and the airline industry to protect the masses in the airport critical infrastructure. The challenge still remains of how to protect soft targets collectively.

Establishing policies and environmental counter-measures to be people-centric provides this opportunity. The environmental elements of CPTED provide strategic methods for crowd-protection and can fill the gap of physically securing the soft targets. If applied strategically, these features can minimize threat impact, afford resiliency, and boost continuity of operations. A systematic approach to STS can save billions of dollars for the aviation industry, airport infrastructure, commerce, and the U.S. economy. As passenger numbers continue to increase in airports worldwide, it is imperative to take a proactive stance to mitigate the risk of attacks on innocent civilians.

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I. INTRODUCTION

Aviation security is a pinnacle component of the transportation security sector. Previous airline hijackings and the terrorist events of September 11, 2001 exemplify the physical, economic, and psychological effects of attacks on aviation. The security of the United States' homeland is affected by both the domestic and international security of aviation. Due to the fact that threats to the homeland can arrive from many different directions, it is imperative that the United States implements a comprehensive and sustainable security program with its domestic and international partners. Although the events of 9/11 changed the policy landscape of securing the skies in the United States, many lessons can still be learned.

The terrorist incidents at the airports of Brussels in 2016, Los Angeles in 2013, and Glasgow in 2007 demonstrated the vulnerability of soft targets in the public spaces of airports. In Brussels, malicious actors packed several pieces of luggage with explosives and detonated them in the crowded spaces of the terminal. In the case of Los Angles, an active shooter killed a Transportation Security Administration (TSA) officer and injured several others. In Glasgow, terrorists attempted to enter the terminal building with a vehicle packed with explosives. These attacks occurred in terminal public areas and clearly demonstrate the vulnerability of soft targets.[1] The number of terror attacks on soft targets is increasing, which presents a clear need for a viable solution for soft target security (STS).

An attack on individuals in the airport can cause devastating life loss and severely impact commercial aviation, which results in airports shutting down with millions of dollars lost to the industry and the American economy. The psychological impact of a catastrophic event may also debilitate air travel. Researchers point to the airport as a system-of-systems in the complex world of aviation.[2] A shutdown or disruption in one

[1] Bart Elias, David Randall Peterman, and John Frittelli, *Transportation Security: Issues for the 114th Congress*, CRS Report No. RL33512 (Washington, DC: Congressional Research Service, 2016), https://fas.org/sgp/crs/homesec/RL33512.pdf.

[2] Jeffrey C. Price and Jeffrey S. Forrest, *Practical Aviation Security, Predicting and Preventing Future Threats* (Burlington, MA: Elsevier, 2009), 50.

area causes multiple effects in the national airspace system, both nationally and internationally.[3]

Since 2011, 14 attacks on airports have occurred worldwide.[4] Price and Forrest attest that "airport attacks are the third major form of attack against the global aviation system."[5] Approximately two million passengers travel by air in the United States daily, and the numbers are growing.[6] As annual passenger loads increase in the United States and globally, it becomes more critical to protect the airport grounds. For example, in April 2017, 70.3 million domestic and international enplanements happened on U.S. airlines with an annual increase of 3.1% on domestic flights and 7% increase on international flights. Between 2003 and 2015, U.S. airlines' total passenger enplanements increased by 25% (domestic and international).[7] By 2024, or sooner, the TSA will "likely be screening over one billion people annually."[8] The growing number of airline passengers demonstrates a need to increase the safety of the traveling public in airports.

The flow of passengers from multiple airline ticket counters toward one common screening checkpoint causes large queues with high passenger wait times, sometimes exceeding 40 minutes.[9] At Category X airports (hub airports with greatest volume of passenger enplanements), more than 1,000 passengers were screened per hour (pph)

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[3] Price and Forrest, 50.

[4] "Recent Airport Attacks at a Glance," Associated Press, June 29, 2016, https://apnews.com/4950118bb7e944c6b3bc8045b39bd24e. This article does not include the Florida Fort Lauderdale active shooter event on January 6, 2017.

[5] Price and Forrest, *Practical Aviation Security*, 50.

[6] "Media, Press Releases," Transportation Administration Agency, January 21, 2016, https://www.tsa.gov/news/releases/2016/01/21/tsa-releases-2015-statistics.

[7] "Passenger Travel Facts and Figures; Chapter 2: Passenger Travel," U.S. Department of Transportation, Bureau of Transportation Statistics, accessed November 20, 2016, http://www.rita.dot.gov/bts/publications/passenger_travel_2016/chapter2. Enplanement is defined as the number of passengers that board a plane.

[8] Bart Elias, *Airport Passenger Screening: Background and Issues for Congress*, CRS Report No. R40543 (Washington, DC: Congressional Research Service, 2009), 2, https://fas.org/sgp/crs/homesec/R40543.pdf.

[9] Elias, Peterman, and Frittelli, *Transportation Security*, 2.

during peak operational hours.[10] Since passengers waiting in a queue are *de facto* confined and cannot easily disperse from an attack, these soft targets become security vulnerabilities. No physical barriers have been erected to mitigate an attack that causes the loss of life, such as blast proof materials to absorb and disperse blast energy. The annual increase of passengers in the aviation transportation sector expounds the need for the careful consideration of measures. Given the ongoing instability in the world, it is important to identify strategies that protect the traveling public, transportation infrastructure, and commerce.

A. PROBLEM STATEMENT

Security measures and technology for the protection of airplane hijackings have increased since 9/11 to include enhanced screening equipment and procedures, expansive list of prohibited items, reinforced cockpit doors, armed federal flight deck officers (FFDOs), increase in federal air marshals (FAMs) and increase of control to sterile area access.[11] All these measures decrease the vulnerability of aircraft to the threat of hijackings or planted explosives. Prior to screening, however, airport terminals are easily accessible to the general public. Current practices provide essentially no defense against adversaries who seek to harm the crowds of traveling passengers prior to security checkpoint screening.

Presently, in the United States, security measures include police patrols, canine teams, and video surveillance. These deterrence countermeasures are confined in scope and ubiquity among the airports nationwide. For example, canine teams are not utilized in medium to smaller sized airports, video surveillance may be scarce, and police patrols

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[10] U.S. Government Accountability Office, *Transportation Security Information Sharing: Results of GAO's Survey of Stakeholder Satisfaction with TSA Products and Mechanisms*, GAO-12-67SP (Washington, DC: U.S. Government Accountability Office, 2012), http://www.gao.gov/special.pubs/gao-12-67sp/; Geraline K. Leone and Sanchoy Das, "Operating Characteristics of Passenger Screening Processes and the Development of a Paced Inspection System," Executive Committee for the Interdisciplinary Program in Transportation, New Jersey Institute of Technology's Electronic Thesis & Dissertations Project, 6, January 2010, https://www.researchgate.net/publication/281655949_Operating_characteristics_of_passenger_screening_processes_and_the_development_of_a_paced_inspection_system; Price and Forrest, *Practical Aviation Security*, 15. Large hub airports account for 70% of annual total passenger enplanements in the United States.

[11] "Transportation Security Timeline," Transportation Security Administration, accessed August 20, 2017, https://www.tsa.gov/timeline.

vary in patrolling times and locations. The TSA has examined several vectors where additional countermeasures may be implemented; particularly in pre-screening passengers, checkpoint screening, and aircraft hardening measures. Terrorism counter-measures in public terminal spaces, however, need further exploration.[12] Recent events have shown that crowds of passengers (soft targets) in the terminal spaces are becoming the adversaries' next opportunistic target.[13]

Protecting crowded terminal spaces is challenging because the Aviation Transportation Security Act (ATSA) does not specifically mandate how to implement this task. Airport security is contingent upon a partnership between airport boards, airlines, police, the TSA, the Federal Aviation Administration (FAA), and stakeholders; and each airports configuration and relationship is unique. Price and Forrest attest to the fact that:

> Although the TSA provides regulatory oversight over airport security practices, it is the airport operator who must develop and implement prescribed security practices. A misunderstanding resulting from this is that the federal security director (FSD), employed by the TSA, is "in charge" of security at commercial service airports.[14]

Hence, the TSA may have the primary responsibility to ensure the protection of the nation's aviation transportation system in the approximately 440 commercial U.S. airports; however, the "airport operators have direct responsibility for implementing security requirements in accordance with their TSA-approved airport security programs."[15]

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[12] Price and Forrest, *Practical Aviation Security*, 15; "Transportation Security Overview, Improving Security through Layered, Risk Based Approach," U.S. Department of Homeland Security, September 10, 2015, https://www.dhs.gov/transportation-security-overview.

[13] Scott Stewart, "The Evolution of Airport Attacks," Security Management, April 1, 2017, https://sm.asisonline.org/Pages/The-Evolution-of-Airport-Attacks.aspx.

[14] Price and Forrest, *Practical Aviation Security*, 149.

[15] U.S. Government Accountability Office, *Aviation Security: Airport Perimeter and Access Control Security Would Benefit from Risk Assessment and Strategy Updates*, GAO-16-632 (Washington, DC: U.S. Government Accountability Office, 2016), 2, 7–9, 13, https://www.gao.gov/products/GAO-16-632.

1. Airport Secure Areas

The majority of commercial airports are divided into three security designated areas: the security identification display area (SIDA), air operations area (AOA), and sterile area (see Figure 1).[16] These three areas are collectively known as security-restricted areas or *sterile areas* and are governed by Title 49 CFR §1542.[17] Individuals and employees must be screened or have the appropriate access control identification criteria to gain access to these areas. As illustrated by the dark blue area in Figure 1, TSA's scope of control in the airport grounds is limited. The *non-sterile* public terminal area is separated from the *sterile area* by a TSA security-screening checkpoint, physical walls, and SIDA access points.

[16] U.S. Government Accountability Office, *Aviation Security*, 11; Price and Forrest, *Practical Aviation Security*, 15.

[17] U.S. Government Accountability Office, 11; Price and Forrest, 160.

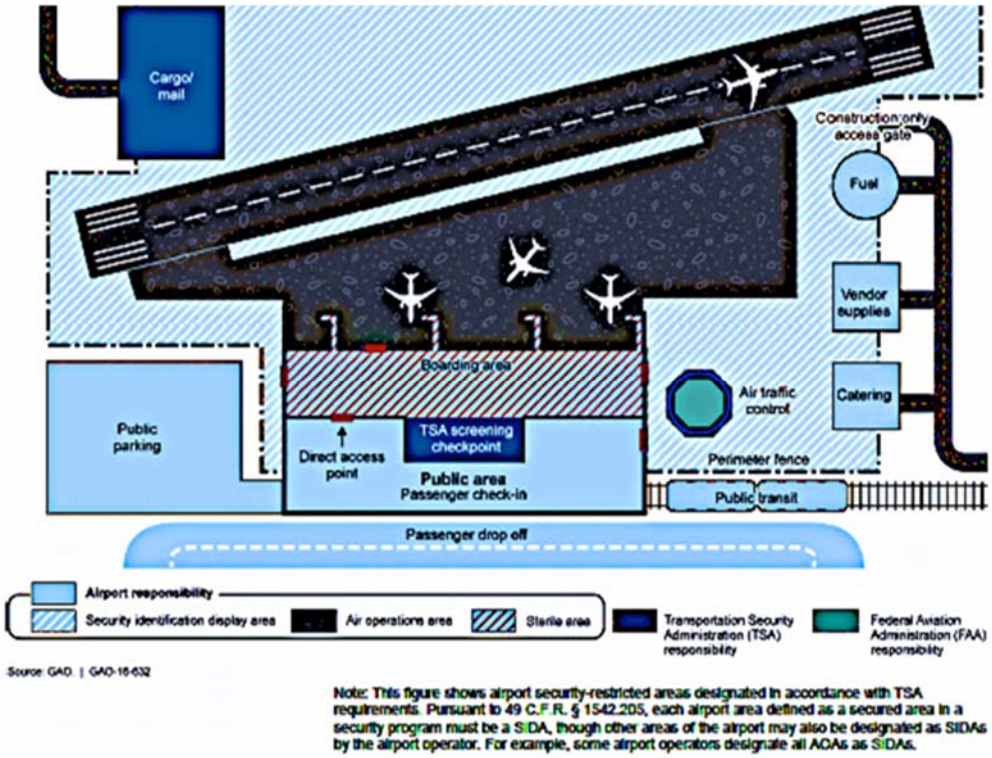

Figure 1. Airport Designated Secure Areas.[18]

The requirement of each airport security program (ASP) is governed by Title 49 CFR Part §1542.101, and is "the foundation for the entire airport security system" for commercial and general aviation.[19] A representative airport security coordinator (ASC) composes the ASP, which describes how the specific airport will comply with federal regulation requirements. ASPs are unique to each airport and must be approved by the TSA.[20] The ASP mainly outlines access control measures, law enforcement requirements, credentialing, employee background checks, access control, security training programs for employees, delineation of security-restricted areas, incident management processes, and the airport's compliance measures.[21] Price and Forrest admit that, "because each airport is unique in physical and operational characteristics, the ASP (customized for

[18] Adapted from U.S. Government Accountability Office, *Aviation Security*, 12.

[19] Price and Forrest, *Practical Aviation Security*, 151.

[20] U.S. Government Accountability Office, *Aviation Security*, 8.

[21] Price and Forrest, *Practical Aviation Security*, 151.

each airport) functions as the "regulation" for that airport." Additionally, the U.S. Government Accountability Office posits, "The details of these programs and their implementation can differ widely based on the individual characteristics of airports."[22] Hence, airports across the nation are not standardized in their approach to aviation security. The ASP and ATSA does not cover, or presently mandate, how to protect crowded spaces in non-secure areas.[23] The lack of a standardized program to protect the traveling public makes it difficult to secure soft targets in aviation transportation.

Environmental design for the security of soft targets in the airport may provide an opportunity to fill this gap. The goal of this thesis is to evaluate and prescribe how airport environmental design principles can better safeguard masses of people in the terminal spaces and passenger queues. This thesis proposes to find new solutions and alternative methods to protect crowds from malicious attacks, to mitigate life loss, and protect the industry and commerce.

2. Research Question

The purpose of the thesis research is to answer the question of how can human perception and environmental design affect an adversary's soft target selection. If environmental design can change, such that the target does not appear attractive, then the adversary will not select it. Specifically, this thesis investigates crime prevention through environmental design (CPTED), human perception of target selection, and policies that have been applied for the protection of soft targets. By exploring patterns, evidence, and ideas that connect the deterrence strategies between the disciplines and industries, the objective is to identify effective environmental deterrence to disrupt the terrorist planning cycle, as well as minimize the impact of an active shooter. This research identifies environmental design strategies that work in airport spaces, as well as those that may not transfer effectively. The aim is to enhance prevention and build resiliency.

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[22] U.S. Government Accountability Office, *Aviation Security*, 10.

[23] "Title I—Aviation Security," Congress, accessed August 20, 2017, https://www.congress.gov/bill/107th-congress/senate-bill/1447/text?overview=closed.

B. LITERATURE REVIEW

Terrorism tactics have evolved over time, and attacks on private citizens and non-combatants continue to increase. For example, between 2013 and 2014, the Global Terrorism Index shows that deaths of private citizens increased by 172% worldwide.[24] Soft target attacks have recently occurred at Charlie Hebdo (2015), the Paris attacks (2015), the Nice attack (2016), the Pulse Night club (2016), the Manchester attack (2017) and the London attacks (2017). Furthermore since 2011, 14 airports have been attacked around the world.[25] Literature on protecting soft targets has only recently begun to appear, and studies are limited on how adversaries select crowds as targets in the aviation transportation sector.[26]

Thus, the question is how to deter terrorists from seeking to affect aviation by selecting soft targets? First, it is necessary to understand how deterrence works. Significant research has been conducted in deterrence theories, particularly in the field of criminology and conventional war.[27] In comparison, the study of deterrence with suicide terrorism has been studied over several decades. Robert Jervis admits, "until recently we did not even have many case studies of deterrence attempts and deterrence failures."[28] Morral and Jackson also admit "deterrence is a central concept in counterterrorism security, yet it is not well understood or measured."[29] The literature discusses various strategies for terrorism deterrence, and it is a vast growing field.

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[24] "Global Terrorism Index 2015," Institutes for Economics and Peace, 4, November 2015, http://www.visionofhumanity.org/reports/page/2/.

[25] "Recent Airport Attacks at a Glance," Big Story, June 28, 2016, http://bigstory.ap.org/article/4950118bb7e944c6b3bc8045b39bd24e/recent-airport-attacks-glance. The article does not include the shooting in Ft. Lauderdale in January 2017.

[26] Victor H. Asal et al., "The Softest of Targets: A Study on Terrorist Target Selection," *Journal of Applied Security Research* 4, no. 3 (2009): 260, doi: 10.1080/19361610902929990.

[27] Ronald L. Akers, "Rational Choice, Deterrence, and Social Learning Theory in Criminology: The Path Not Taken," *The Journal of Criminal Law and Criminology (1973–)* 81, no. 3 (1990): 653–676, http://www.jstor.org/stable/1143850.

[28] Robert Jervis, Richard Ned Lebow, and Janice Gross Stein, *Psychology and Deterrence* (Baltimore, MD: Johns Hopkins University Press, 1985), 1.

[29] Andrew Morral and Brian A. Jackson, *Understanding the Role of Deterrence in Counterterrorism Security* (Santa Monica, CA: RAND, 2009), 1, http://www.rand.org/pubs/occasional_papers/OP281.html.

1. Deterrence and Human Perception of Soft Targets

The Department of Homeland Security's (DHS) risk lexicon defines deterrence as "a measure that discourages an action or prevents an occurrence by instilling fear, doubt, or anxiety."[30] Hence, for deterrence to work, a human must perceive a negative emotional response. Deterrence theories for the protection of national security assets date back to 1985, and were mainly applied during the Cold War era.[31] Jervis discussed a state's role in deterrence via punishment and retaliation strategies, which are still applied to state-actors today.[32] Deterrence of terrorism, however, was only briefly mentioned in his work during this period. Jervis explained how state actors could deter terrorism through policy or military action. This topic is discussed in the literature, however, concerning which components of deterrence theory state actors should apply to terrorism (i.e., punishment, retaliation, or denial).[33]

The TSA philosophy in deterring terrorism is increasing risk (cost) for the terrorist action, which also works in detecting the threat. The TSA "20 Layers of Security" attest to this notion (see Appendix A). TSA's layers of security cover the multiple vectors of transportation security in aviation as follows:

- Intelligence
- Customs and Border Protection
- Joint Terrorism Task Force
- No-Fly List And Passenger Pre-Screening
- Crew Vetting

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[30] U.S. Department of Homeland Security, *Risk Steering Committee, DHS Risk Lexicon* (Washington, DC: U.S. Department of Homeland Security, 2010), 51, https://www.dhs.gov/sites/default/files/publications/dhs-risk-lexicon-2010_0.pdf.

[31] Richard Ned Lebow and Janice Gross Stein, ed., *Psychology and Deterrence* (Baltimore, MD: Johns Hopkins University Press, 1985).

[32] Robert F. Trager and Dessislava P. Zagorcheva, "Deterring Terrorism, It Can Be Done," *International Security* 30, no. 3 (Winter 2005/2006): 88–89, doi: 10.1162/isec.2005.30.3.87.

[33] Trager and Zagorcheva, 95–98.

- VIPR
- Canine
- Behavior Detection
- Travel Document Checker
- Checkpoint/TSOs
- Checked Baggage
- Transportation Security Inspectors
- Random Employee Screening
- Transportation Security Specialists-Explosives
- Federal Air Marshals
- Federal Flight Deck Officers
- Trained Flight Crew
- Law Enforcement Officers
- Hardened Cockpit Doors
- Passengers[34]

Additionally, Burns, Dillon-Merrill, and John have conducted significant work in studying terrorism-countermeasures in the affective *vectors* of aviation transportation.[35]

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[34] Bob Burns, "Inside Look: TSA Layers of Security," *Transportation Security Administration* (blog), August 1, 2017, https://www.tsa.gov/blog/2017/08/01/inside-look-tsa-layers-security; Mark G. Stewart and John Mueller, *Risk-Based Passenger Screening: Risk and Economic Assessment of TSA PreCheck Increased Security at Reduced Cost?* (Callaghan, Australia: University of Newcastle, Center for Infrastructure Performance and Reliability, 2016), 5, http://hdl.handle.net/1959.13/1313869.

[35] William J. Burns, Robin Dillon-Merrill, and Richard John, *Dynamic Aviation Risk Management Solution (DARMS): A Proof of Concept Study Examining Analysis of Terrorism Events* (Los Angeles: National Center for Risk and Economic Analysis of Terrorism Events, USC, 2015), http://create.usc.edu/sites/default/files/projects/sow/3044/tsadarmsmauuncertaintyreportmarch27v1.pdf.

One area that needs further examination in these vectors and layers is the protection of the passengers in the TSA checkpoint queues and terminal public spaces where crowds form.

a. Deterrence and Risk-Based Security

Recent studies in the deterrence of terrorism involve risk management and are explained through rational choice theory, game theory, prospect theory, utility theory, and the benevolence system.[36] Theories of risk management have been borrowed from the field of economics, and extensive literature supports this approach on aviation transportation. Both game theory and prospect theory have been applied as risk management techniques.[37] Slovic made game theory behavioral observations through experimental design, whereas Burns, Dillon-Merrill, and John applied these risk management theories in the various vectors of aviation transportation. For example, Burns, Dillon-Merrill, and John discovered how risk management models could be applied from pre-screening (buying an airline ticket), through passenger screening, canine handling, and boarding a plane. They are also working on developing risk mitigation factors within each of these vectors to consider a *dynamic approach* to transportation security.[38] The application of these risk factors would deter an adversary from seeking the asset as a target. In other words, motivating or influencing the adversary that the target is hopeless can increase denial of the target.

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[36] Jeffrey D. Berejikian, "A Cognitive Theory of Deterrence," *Journal of Peace Research* 39, no. 2 (2002): 165–183, doi: 10.1177/0022343302039002002; Burns, Dillon-Merrill, and John, *Dynamic Aviation Risk*; Bruno S. Frey and Simon Luechinger, "How to Fight Terrorism: Alternatives to Deterrence," *Institute for Empirical Research in Economics* 14, no. 4 (2003): 237–249; Jervis, Lebow, and Stein, *Psychology and Deterrence*.

[37] Berejikian, "A Cognitive Theory of Deterrence"; Todd Sandlar and Daniel G. Arce M., "Terrorism and Game Theory," *Forthcoming Simulation & Gaming* 34, no. 3 (September 2003), www.utdallas.edu/~tms063000/website/Terror_Games.pdf; Ken Fletcher, "Aviation Security: A Case for Risk-Based Passenger Screening" (master's thesis, Naval Postgraduate School, 2011); Matthew Kroenig and Barry Pavel, "How to Deter Terrorism," *The Washington Quarterly* 35, no. 2 (2012): 21–36, doi: 10.1080/0163660X.2012.665339; Ben Sheppard, "Mitigating Terror and Avoidance Behavior through Risk Perception Matrix to Augment Resilience," *Journal of Homeland Security and Emergency Management* 8, no. 1 (2011): 1–19, doi: 10.2202/1547-7355.1840.

[38] Burns, Dillon-Merrill, and John, *Dynamic Aviation Risk*.

Game theory and utility theory have been utilized in TSA's risk based security (RBS) model since 2014.[39] Both theories focus on how people interact in a given situation and their prospective outcomes. Game theory examines "how intelligent individuals interact with one another in an effort to achieve their own goals" by listing each player in game and listing alternative choices.[40] Utility theory is an economic concept applied to terrorism studies that state that "the utility derived from a good or service [is ranked based] on possible alternatives in their order of preference to the consumer."[41] Since this "choice is constrained by the price and the income of the consumer, the rational consumer will not spend money on an additional unit of good or service unless its marginal utility is at least equal to or greater than that of a unit of another good or service."[42] Therefore, the consumer's decision-making process depends on marginal utility of the service or product. In terrorism studies, targets and measures of success are applied through this concept. In other words, the terrorists will apply a type of cost-benefit analysis to their available alternative operations and plots while seeking out attack opportunities.[43]

The aforementioned deterrence theories discuss the challenger's role in calculation, intention, target selection, and capabilities.[44] Target selections and terrorism tactics have shifted since the time of the Cold War and nuclear threat focus, which were primarily focused on *deterrence-by-punishment* or *deterrence-by-retaliation*.[45] Literature and research for the current terrorist deterrence to the United States, in particular, are still developing and no common consensus exists on which approach is most effective. As Kroenig and Pavil observe, "the deterrence approach remains a poorly understood and

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[39] Fletcher, "Aviation Security," 7; Price and Forrest, *Practical Aviation Security*;" Burns, Dillon-Merrill, and John, *Dynamic Aviation Risk*; "Factsheets," Transportation Security Administration, accessed May 1, 2017, https://www.tsa.gov/press/factsheets.

[40] David Levine, "Economic and Game Theory, What is Game Theory," University of California, Los Angeles, accessed November 21, 2016, http://levine.sscnet.ucla.edu/general/whatis.htm.

[41] *Business Dictionary*, s.v. "utility theory," accessed January 17, 2017, http://www.businessdictionary.com/definition/utility-theory.html.

[42] *Business Dictionary*.

[43] Morral and Jackson, *Understanding the Role of Deterrence*, 3.

[44] Sandler, "Terrorism and Game Theory"; Kroenig and Pavel, "How to Deter Terrorism."

[45] Kroenig and Pavel, 23.

underutilized element of U.S. counterterrorism strategy [and holds] great potential for helping to thwart future terrorist attacks."[46]

Certain deterrence theories discuss retaliation and punishment strategies as techniques in averting the adversary through hostile action.[47] Historically, these theories have been applied in the criminology field.[48] Suicide bombers, however, seek to maximize their advantage through the loss of their own lives. Thus, obviating terrorists with only punishment or retaliation may not prove successful.[49] Kroenig and Pavel attest that the United States cannot deter against all terrorism activities and disaggregating terrorist networks requires breaking them up into their component parts.[50] Therefore, deterrence should be viewed through the individual or organizational approach. For passenger queuing and the deterrence of the soft target, the countermeasures should be viewed as a systems approach. As discussed earlier, the airport is only one of many parts of the aviation industry, and an effect in one part can have multiple ripple effects in others (nationally and internationally). Thus, threats from both individuals and groups/organizations need to be considered.

Trager and Zagorcheva suggest that deterrence strategy consist of two elements, "(1) a threat or action designed to increase an adversary's perceived costs of engaging in particular behavior, and (2) an implicit or explicit offer of an alternative state of affairs if the adversary refrains from that behavior."[51] The first point is interesting because it explains the cost-benefit analysis of target selection. Thus, if the suicide bomber does not meet his objective successfully (cost), that target is not worth selecting. The second point, which the authors call deterrence-by-denial, "involves 'hardening' targets in the hope of making an attack too costly to be tried."[52] In this term, "hardening the target" signifies

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[46] Kroenig and Pavel, 22.

[47] Kroenig and Pavel, 25.

[48] Akers, "Rational Choice."

[49] Kroenig and Pavel, "How to Deter Terrorism," 25.

[50] Kroenig and Pavel, 24.

[51] Trager and Zagorcheva, "Deterring Terrorism," 90.

[52] Trager and Zagorcheva, 91.

investing resources for target protection, which will persuade the terrorist to seek another target.[53] In the case of soft target selection, this model offers a plausible solution towards deterrence. If by some means the target is seen as a high risk to engage in attack, then the likelihood of attack aversion or displacement is increased.

Risk transfer and displacement is a factor that needs to be considered with deterrence because successful deterrence measures in one area can increase danger levels in another.[54] Morral and Jackson state that the "potential for risk displacement makes understanding the deterrent effect of a security program a systems problem."[55] TSA's RBS system, which moved screening from a one-size fits-all approach to a risk-informed, intelligence driven approach, derived from game theory and risk management.[56] Thus, the philosophy is that all risk cannot be deterred, but levels of risk can be assigned to calculate acceptable losses. It is important to understand how deterrence and risk displacement can impact other vectors of security. Although the argument of risk transference is beyond the scope of this paper, the TSA layers of security do take into consideration the different facets that impact security capacity in the various system levels mandated by ATSA.

Trager and Zagorcheva describe hardening targets by "fortifying,.. reinforcing… upgrading.. and tightening.. controls."[57] The authors state, "although defensive strategies cannot protect every target, they can minimize the terrorist's power to hurt, thereby lessening the coercive power of terrorist action."[58] Morral and Jackson affirm that ideally, "deterrence and risk-displacement effects are 'designed in' so that security measures manipulate terrorist decision-making in ways that produce net security

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[53] Eli Berman and David D. Laitin, *Hard Targets: Theory and Evidence on Suicide Attacks*, Working Paper 11740 (Cambridge, MA: National Bureau of Economic Research, 2005), 10, doi: 10.3386/w11740.

[54] Morral and Jackson, *Understanding the Role of Deterrence*, 1.

[55] Morral and Jackson, 26.

[56] U.S. Department of Homeland Security, *2014 Quadrennial Homeland Security Review* (Washington, DC: Department of Homeland Security, 2014), 32–33, https://www.dhs.gov/sites/default/files/publications/qhsr/2014-QHSR.pdf.

[57] Trager and Zagorcheva, "Deterring Terrorism," 106.

[58] Trager and Zagorcheva, 106.

benefits."[59] Thus, the countermeasure for the terrorist planning and decision-making phase is a key element in developing deterrence techniques. They also recommend designing in security countermeasures. These decision-making strategies are discussed in the following sections.

b. Terrorist Planning Cycle

The terrorist planning cycle provides a substantive frame of reference when modeling where the deterrence measures need to be interjected in the aviation transportation sector (see Figure 2).[60] According to Dr. George Habash (founder of the Popular Front for the Liberation of Palestine), "the main point [for the terrorist] is to select targets where success is 100% assured."[61] This point is logical because suicide terrorists want to maximize causality loss in their chosen operation. The two areas where deterrence counter-terrorism strategies may have the most impact are in the *intelligence and surveillance* and *pre-attack surveillance and planning cycle* (see Figure 2).[62]

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[59] Morral and Jackson, *Understanding the Role of Deterrence*, 1.

[60] Stephanie Clark, "Interdiction of Terrorist Planning and Surveillance," MSA Security, November 17, 2015, http://www.msasecurity.net/Security-and-Counterterrorism-Blog/Interdiction-of-Terrorist-Planning-and-Surveillance.

[61] George Habash, "Appendix A, Terrorist Planning Cycle," in *A Military Guide to Terrorism in the Twenty-First Century, Appendix A, Terrorist Planning Cycle, U.S. Army Training and Doctrine Command DCSINT Handbook No. 1* (Fort Leavenworth, KS: U.S. Army Training and Doctrine Command, 2007), A-1, https://fas.org/irp/threat/terrorism/guide.pdf. A-1–A-6; Morral and Jackson, *Understanding the Role of Deterrence*, 2.

[62] Habash, "Appendix A, Terrorist Planning Cycle."

Figure 2. Terrorist Planning Cycle.[63]

During these two phases, the terrorists are in the physical environment they are targeting. Terrorists conduct *pre-attack surveillance* to reduce and manage operational risk.[64] If the target at this level reveals a high level of risk in attack objective, or if the target is not perceived as attractive, then the terrorists will deny the target and deterrence countermeasures will succeed. Morral and Jackson describe this cost-benefit-analysis that terrorists make, and they emphasize that low-value targets have deleterious effects on the individual and group objectives.[65] To clarify, however, this strategy may be successful with suicide terrorists but may not be as effective with other adversaries, such as active shooters, irrational plotters, or sporadic threats. Nevertheless, the planning cycle provides a crucial element in deciding where and how to implement countermeasures by increasing *uncertainties* for the terrorist decision-maker, which Morral and Jackson believe are "rarely treated explicitly in game-theoretic analysis of terrorist decision-making."[66]

The terrorist planning cycle offers a practical frame to develop countermeasures to protect aviation transportation and soft targets. Morral and Jackson's "Model Decision

[63] Source: Clark, "Interdiction of Terrorist Planning."

[64] Morral and Jackson, *Understanding the Role of Deterrence*, 2.

[65] Morral and Jackson, 3.

[66] Morral and Jackson, 4.

Calculus for a Terrorist Attack" shows an exceedence probability curve for two terrorist operation scenarios based on a terrorist's perceived probabilities of payoffs (see Figure 3).[67] This utility cost curve demonstrates that the attack payoff is higher than the expected costs, hence, making the terrorist value the objective operation, regardless of the trade-off the terrorists face in these two scenarios. The authors note, however, that each organizational group's prerogative is based on different strategies; whether it is maximizing net expected utilities, or minimizing net negative utilities.[68] They stress that "security can be used to manipulate the operational planning of terrorists," in that "security can be designed to increase a terrorist's views of expected disutilities."[69] Several decision factors influence these views that are described as follows.

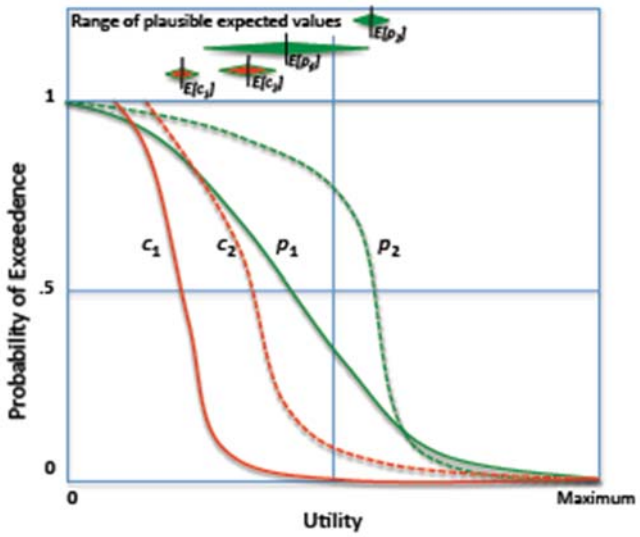

Figure 3. Model Decision Calculus for a Terrorist Attack.[70]

The authors provide the following key decision factors as strategies to influence terrorists' perspectives:

[67] Morral and Jackson, 4. The model decision calculus provides a list of decision factors to consider.

[68] Morral and Jackson, 6.

[69] Morral and Jackson, 6.

[70] Source: Morral and Jackson, 6. Reprinted with permission.

- Raise the costs of an operation (increasing an attacker's expected disutilities)
- Drive up the cost of operations (direct costs in terms of time, money, lives of suicide attackers)
- Drive up opportunity costs (trade-offs between different types of attacks)
- Lower the expected payoff of an operation (terrorist perceptions will drive targeting and tactical planning)
- Increase uncertainties involved in operational payoffs and costs (prefer lower levels of uncertainty)
- Increase uncertainties about defensive capabilities
- Increase tactical uncertainties
- Expose attackers to unpredictable security measures
- Exchange the relative expected utility of alternative operations[71]

According to Morral and Jackson, the aforementioned strategies need to be considered through the lenses of *strategic*, *operational*, and *tactical* deterrence because each counterterrorism security measure has a different outcome.[72] For the purpose of this thesis, strategic deterrence would encompass the entire aviation system; operational deterrence would encompass a screening checkpoint; and a tactical deterrence would encompass terrorist weapon choice. Implementing these strategies is helpful in altering the terrorist utility perspective. Hence, the terrorist planning cycle and utility theory offer a valuable framework for critically thinking about countermeasures, resiliency in infrastructure, and the "actions on the objective" of the threat. It appears that, more

[71] Morral and Jackson, *Understanding the Role of Deterrence*, 6–15. See Morral and Jackson for the detailed discussion of each subject area. I have summarized them in these bullet points, which are discussed from pages 6–15.

[72] Morral and Jackson, 15.

recently, the utility of a soft target attacks are of the same order as attacks against "harder" targets. Furthermore, the costs of attacking soft targets, in terms of political or moral capital, now appear to be small. Thus, few alternatives remain; the role of the defender, now, has two basic options, (1) "harden" the soft targets, or (2) increase the costs associated with attacking soft targets.

c. Human Perception

As discussed previously, game theory and utility theory demonstrate an adversary's mindset and perception when determining who and what to attack.[73] Frey and Luechinger claim that game theory also explains how an adversary perceives and calculates risk when planning to attack.[74] Prospect theory can be applied in understanding how an attack on soft targets can have positive utility for an adversary.[75] For example, Morrel and Jackson describe how lowering the expected payoff of a terrorist operation (from the terrorist's perspective) can provide useful insight to abandon or delay an attack.[76] Therefore, although deterrence theory does not specifically address how to deter an attack on crowds of innocent civilians, ample research in its application justifies transposing it to the protection of soft targets.

Previous authors have not specifically considered the threat to soft targets, such as crowds of people in the airport environment. The main focus in aviation security has been on preventing pre-9/11 threats, such as airplane hijackings, bombs, and weapons entering aircraft and the sterile side of an airport (TSA regulations governed by the Aviation Transportation Security Act).[77] However, a knowledge gap remains in the literature on deterrence in relation to plausible terrorist attacks on soft targets in airport settings.

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[73] Berejikian, "A Cognitive Theory of Deterrence," 165–183.

[74] Bruno S. Frey and Simon Luechinger, *How to Fight Terrorism: Alternatives to Deterrence* (Zurich: University of Zurich, 2002), 5, 17.

[75] Frey and Luechinger, 8, 10, 18–19.

[76] Morral and Jackson, *Understanding the Role of Deterrence*, 9.

[77] Title I—Aviation Security, Public Law 107 (2001), 71; National Commission of Terrorist Attacks upon the United States, *The 9/11 Commission Report: Final Report of the National Commission of Terrorist Attacks upon the United States* (New York: W. W. Norton, 2004).

Perception and *influence* countermeasures toward soft targets could harden the target and provide deterrence in suicide terrorism. This technique can be applied through the use of environmental design in physical infrastructure. According to Coaffee et al., "spatial design, material choices, aesthetics and many other 'design' factors can influence a location's vulnerability to attack."[78] Of course, hardening the physical infrastructure is just one element within the multilayered approach to soft target deterrence. At the present moment, TSA passenger queues or terminal crowded spaces do not offer any protection toward attacks. In essence, everything is out in the open and visible.

Physical design does not have to be viewed as harsh. Ample research in Gestalt psychology, art, architecture, and engineering attests to the fact that design itself can influence behavior.[79] The TSA passenger queue or crowds can be made to *appear* smaller through the use of geometric shapes, lines, colors, width, and height of structures. These techniques have been applied in the iconic optical illusions, such as the Ames Room, Muller-Lyer, and Ponzo line illusions (see Figures 4 and 5).[80]

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[78] Jon Coaffee et al., "Resilient Design for Community Safety and Terror-Resistant Cities," in *Proceedings of the ICE: Municipal Engineer* 161, no. 2 (2008): 107, https://dspace.lboro.ac.uk/dspace-jspui/handle/2134/9204.

[79] Richard H. Thaler and Cass R. Sunstein, *Nudge: Improving Decisions about Health, Wealth, and Happiness* (New York: Penguin Books, 2009), 110, 135–139.

[80] Nynke Tromp, Paul Hekkert, and Peter-Paul Verbeek, "Design for Socially Responsible Behavior: A Classification of Influence Based on Intended User Experience Design Issues," *Massachusetts Institute of Technology Design Issues* 27, no. 3 (2011): 3–19, doi: 10.1162/DESI_a_00087.

Figure 4. Ames Room.[81]

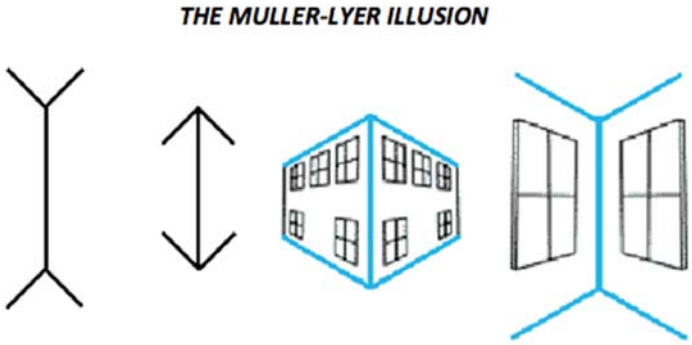

Figure 5. Muller-Lyer Lines.[82]

Verstegen describes perceptual illusions in architecture and provides evidence in the book *Cognitive Iconology*.[83] Figure 6 is an example he shows of the illusion of shapes

[81] Source: "Ames Room," Illusion Works, LLC., 1997, http://psylux.psych.tu-dresden.de/i1/kaw/diverses%20Material/www.illusionworks.com/html/ames_room.html. An Ames room is a structure that causes the perception of a smaller and larger object to appear significantly contrasted, when in reality, the two are the same.

[82] Source: Ria Thompson, "Visual Illusions: The Muller-Lyer Illusion," Prezi, December 7, 2015, https://prezi.com/sm1r7yoij6em/visual-illusions-the-muller-lyer-illusion/. The Muller-Lyer lines demonstrate perception in lines. Although the lines are exactly the same length, due to their orientation, they make an object appear smaller or larger. This is a depth perception illusion.

[83] Ian Verstegen, *Cognitive Iconology, When and How Psychology Explains Images* (Amsterdam: Rodopi, 2014), http://www.brill.com/products/book/cognitive-iconology#BIONOTE_1, https://books.google.com/books?id=Rr32oAEACAAJ&dq=isbn:9789042038240&hl=en&sa=X&ved=0ahUKEwi6v6btgrHYAhXqjFQKHbwjD_YQ6AEIKTAA.

with and without lines. Figure 7 demonstrates the perceptual movement of the eye, as if the shape was rotating. These examples illustrate how perception influences how people see and understand the environment and the objects around them.

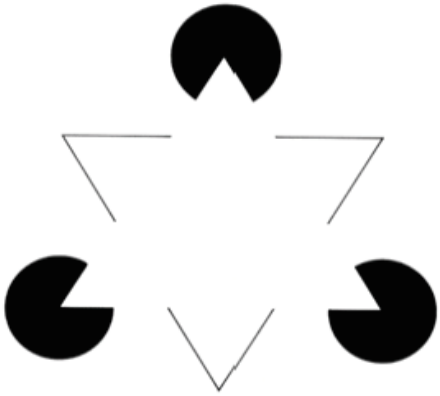

Figure 6. Illusory Contour Devised by Gaetano Kanizsa.[84]

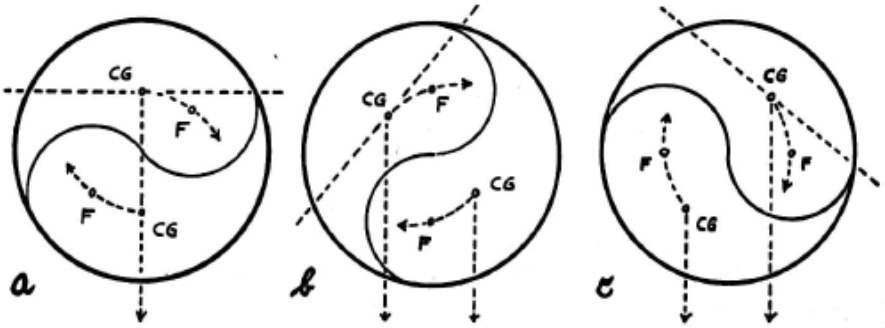

Figure 7. From Arnheim (1966).[85]

Geometric designs used in architecture, art, and infrastructure to create visual perceptions in imagery have been used by Leonardo da Vinci, and Massironi's and Savardi's cross-ration to trick the mind into seeing shapes and lines forming specific

[84] Source: Verstegen, 15.

[85] Source: Verstegen, 21.

patterns. [86] These techniques can provide benefits in the protection of the soft targets and the perception of the passenger queue or terminal crowded spaces. Thus, design can incorporate these types of illusionary elements to aesthetically provide a visual cue of deterrence by making the passenger lines look smaller. The negative aspect is that experts would have to be employed to develop these designs, which may be costly and time consuming. Also, this strategy has not yet been empirically studied in the airport environment or passenger queuing and no literature supports it.

2. Design Measures

In the United Kingdom, where terrorists have attacked crowds in rail stations, inner cities with car bombs, and airport terminal buildings, to name a few, several measures have been instituted to harden soft targets through the use of design planning.[87] Coaffee et al. propose designing an environment that is defensible and resilient. They describe how the UK's counter-terrorism strategy (CONTEST) and projects *Argus* and *Griffin* aim to reduce risk of attack by developing resiliency for counter-terrorism. They affirm that in the United Kingdom, "current research has identified that key stakeholders recognize that resilient design will become central to planning, construction guidelines, and legislation in the near future" and that blast fragmentation resistant materials are increasingly utilized in building design, urban development, and transport systems.[88] They advocate *designing-in* for crime and terrorism. Valuable lessons can be learned from how the United Kingdom adopts these security measures toward soft targets, which may be transferred to the United States.

Security measures that prevent the hijacking of an airliner, bringing explosives on board, and passenger screening measures have become more sophisticated within the last decade in the United States. Adversaries seeking to cause severe harm will minimize the costs and seek *opportunistic attacks*. Wasson and Bluesteen assert that "[modern adversaries'] motivations are diverse and they are increasingly selecting soft targets on

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[86] Verstegen, 16, 74, 85.

[87] Coaffee et al., "Resilient Design," 107.

[88] Coaffee et al., 107.

the basis of opportunity," and they further emphasize "alternative approaches to deterrence are needed that account for this fundamental change."[89] They stress that security professionals should ask themselves not whether an attack will occur, but rather who will be attacked. Additionally, Asal et al. argue that soft targets are mainly chosen by smaller groups of terrorists to instill fear and communicate their political message because they are easy to attack.[90] Frey and Leuchinger also concur that terrorists seek publicity to damage the economy and destabilize politics.[91] These authors point to a fundamental change from previous theories of state-actor deterrence; the shift now focuses on how the adversaries are targeting innocent non-combatants.

In differentiating from prospect and utility theory, Wasson and Bluesteen argue that an adversaries' target choice depends more on their perception of an opportunity. They proclaim that a target is selected based on adversaries' "minimal knowledge" in a given set of choices; and that they choose one over the other not because they want to maximize utility, but rather due to their "casual *perceptions* of opportunity" [authors' emphasis].[92] Thus, they argue that defenders have to make the target appear unattractive and manipulate the potential adversaries' perceptions and intuition so that the target's features cannot be accurately assessed. They believe that this type of deterrence can be achieved through "hyperbolic discounting, illusion of control, and even optical illusions."[93] All these elements are explored in the Security and Environmental Design section that follows.

a. Security and Environmental Design

Environmental designs for the prevention of explosive attacks or active shooter events provide both mitigation toward life loss and deterrence. In the United Kingdom,

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[89] Jesse Wasson and Christopher Bluesteen, "Cognitive Defense; Influencing the Target Choices of Less Sophisticated Threat Actors," *Homeland Security Affairs* 13, no. 1 (2017): 2, https://www.hsdl.org/?view&did=800157.

[90] Asal et al., "The Softest of Targets," 258–278.

[91] Frey and Luechinger, "How to Fight Terrorism: Alternatives to Deterrence," 6.

[92] Wasson and Bluesteen, "Cognitive Defense," 9.

[93] Wasson and Bluesteen, 6.

the National Counter Terrorism Security Office (NaCTSO) is a specialized police force that offers training and coordination for explosives, chemical, pathogenic, and toxins security. Its main objective is to protect crowded spaces from terrorist attacks by instituting physical security through infrastructure design.[94] Furthermore, it partners with local business communities via Project Argus and Project Griffin to raise threat awareness, physical security of blasts, secondary fragments, ground shock, and attack response.[95] The UK's counter-terrorism design principles encompass a holistic approach to environmental design and infrastructure by incorporating both explosive attack and active shooter hardening.

Soft target hardening refers to developing countermeasures to minimize damage to an adversary's target, make the target resilient to attack, and displace the adversary's intent to attack the target. In the literature, *hardening a target* often refers to changing the environment in a manner that makes the target difficult to attack. This hardening entails changing physical structures, such as building blast-proof or bulletproof barriers, increasing surveillance through closed circuit television (CCTV), increasing armed guards, reducing fragmentation and shrapnel, and adding durable mechanisms.

The literature is narrow on the topic of hardening for the protection of terrorist attacks on crowds; however, Coaffee et al. provide an in-depth analysis on this subject. They specifically address how to "design out" terrorism in urban settings in the United Kingdom. They elaborate on the concepts of terrorism countermeasures through environmental engineering and demonstrate how structures in the United Kingdom are currently being built to minimize an explosion impact. They argue that design countermeasures built to protect soft targets could harden the target and provide deterrence against suicide terrorism. Their recommendations can be ubiquitous and provide a permanent solution, unlike the use of canines, which are confined in their ability to safeguard both people and infrastructure.

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[94] Home Office, *Protecting Crowded Places: Design and Technical Issues* (London: Home Office, 2014), https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/302016/Design TechnicalIssues2014.pdf. CONTEST was published in 2011 and its goal is to reduce the international terrorism risk to crowded places in the United Kingdom.

[95] Home Office, 6–9.

Two recent books by Hesterman, Fagel, and Hesterman focus explicitly on the protection of *soft targets*.[96] Whereas Hesterman does not discuss the airport environment, Fagel and Stovall do.[97] Hesterman provides detailed environmental threat assessment tools for use in schools, hospitals, and churches; mainly arguing that hardening should encompass not only building high and secure walls around compounds and facilities, but also extra security guards, evacuation procedures, access control, technology and psychological countermeasures that can be applied to protect soft targets.[98] Her experience derives from extensive military service in overseas assignments. Fagel and Stovall, on the other hand, provide a "soft target threat assessment" as a concept of "defense in depth of layers" approach.[99] They describe a layered approach in evaluating policies, procedures and awareness, physical protection measures, perimeter control, doors and access points, two-factor verification, and finally, the target of protection in the center. Their assessment tool also considers training, planning, exercises, and command centers.

The aforementioned threat assessments are distinctive in the literature regarding soft targets. Not only is this work recent, but it also addresses issues in protecting crowded areas, such as shopping malls, special events, and sports venues. Although literature on this topic exists from a security perspective, historically, it has been mainly concerned with crime, environmental hazards, and health impediments instead of terrorist attacks on crowds, specifically.[100] This focus may be due to its recent emergence in the literature along with the rise of terrorism towards private citizens.[101]

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[96] Jennifer Hesterman, *Soft Target Hardening, Protecting People from Attack* (Boca Raton, FL: CRC Press, 2015); Michael J. Fagel and Jennifer Hesterman, *Soft Targets and Crisis Management* (Boca Raton, FL: Taylor & Francis Group, 2017).

[97] Hesterman, *Soft Target Hardening*, 175–240; Michael J. Fagel and S. Shane Stovall, "Soft Target Planning," in *Soft Targets and Crisis Management*, ed. Michael J. Fagel and Jennifer Hesterman (Boca Raton, FL: CRC Press Taylor & Francis Group, 2017), 393.

[98] Fagel and Stovall, "Soft Target Planning," 393.

[99] Fagel and Stovall, 393.

[100] Tromp, Hekkert, and Verbeek, "Design for Socially Responsible."

[101] "Global Terrorism Index," 22–24, 34. Statistics on the increase of deaths to private citizens was provided at the beginning of the thesis in the literature review section.

In the United States, current airport deterrence measures include the TSA explosive detection canine handler (EDCH) program, local law enforcement canine teams, and local law enforcement patrols. The law enforcement patrols' main objective is to provide command presence and incident response. The purpose of the EDCH program is to detect explosives that may be carried by an individual in the passenger pre-screening queue (before checkpoint screening). Several restrictions, however, are imposed. First, EDCH teams are deployed to TSA pre-determined checkpoints in large hub airports only. Second, the EDCH teams are not used in all U.S. airports. Third, the EDCH program training, certification, and maintenance are expensive and require specialized skill sets, qualifications, and testing periods.[102] Fourth, the canine will not prevent the explosive from detonating. Lastly, the EDCH teams are limited in their area of responsibility (AOR) and operation in public spaces. No universal policy determines the AOR for the TSA canine teams; each situation is handled differently based on a memorandum of agreement (MOU) with the airport.

The approaches in protecting soft targets from terrorism and crime can be different. Literature research on this topic demonstrates a knowledge gap for the protection of the crowds in the airport environment. Lessons from crime prevention may provide a window of opportunity to explore how these elements can be transferred to the area of aviation transportation. These concepts are explored as follows.

b. Crime Prevention through Environmental Design

According to Crowe, Dr. C. Ray Jeffrey first coined the concept of CPTED in 1972.[103] The study of its principles derived from Jeffrey's research in environmental psychology and criminal behavior, and it is mainly applied in the law enforcement field. With over 30 years of experience in CPTED theory, Crowe provides a thorough

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[102] Jennifer Grover, *Homeland Security and Justice: Explosives Detection Canines, TSA Has Enhanced Its Canine Program, but Opportunities May Exist to Reduce Costs*, GAO-16-444T (Washington, DC: Government Accountability Office, 2016), www.gao.gov/assets/660/651725.pdf; TSA, *TSA Canine Training Center Factsheet* (Washington, DC: TSA, n.d.), accessed May 1, 2017, https://www.tsa.gov/sites/default/files/resources/caninetrainingcenter_factsheet_0.pdf.

[103] Timothy Crowe, *Crime Prevention through Environmental Design, Applications of Architectural Design and Space Management Concepts* (Boston: Butterworth-Heinemann, 2000), 1.

description of this field in his book. Several related schools of operation theories and applications have emerged since its inception, and Crowe defines these as CPTED-organized and *mechanical approach* versus *natural approach*, *defensible space, environmental security, natural crime prevention, safer cities, situational crime prevention*, and *place-specific* crime prevention.[104] Each school of thought focuses on specific design factors and their relation to crime prevention. Elements from engineering, architecture, environmental design, and landscaping are amalgamated for the design of physical space. For the purpose of the thesis, the most relevant concept is "environmental security" because it includes hardening targets, establishing social management, and a broad range of crime control strategies.

Whereas Crowe and others claim that the applications of these concepts significantly decrease crime, the efficacy of its principles continues to be debated in the literature.[105] Atlas posits that no scientific feedback methodology exists to test the concepts and hypothesis of architectural designs; however, others, such as Crowe, debate that CPTED concepts have "been proven effective" in public housing environments, transportation, and schools.[106] Nevertheless, CPTED provides a physical systems approach to prevent crime and it is applied in real-world settings. Furthermore, its concepts have been updated by Atlas to incorporate new threats to the crime prevention field, such as terrorism.[107]

Atlas and DiGregorio examine critical infrastructure for explosive resistance design against terrorism. Unlike the previous authors of soft target hardening (Hesterman and Fegal), Atlas and DiGregorio argue that blast-proof materials alone will not prevent an impact. They recommend integrated CPTED design strategy that synthesizes video motion detection, infrared night vision, chemical, and biological sniffers, virtual fences, and biometric access control, among other things, to provide a "transparent approach to

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[104] Crowe, 22.

[105] Crowe, 3.

[106] Crowe, 7; Randall I. Atlas, ed., *21st Century Security and CPTED, Designing for Critical Infrastructure Protection and Crime Prevention* (Boca Raton, FL: Taylor & Francis Group, 2008), 24.

[107] Atlas, *21st Century Security and CPTED*, chapter 10.

building security and infrastructure protection."[108] These concepts are specific to the CPTED literature and are not discussed in soft target hardening, deterrence theory approaches, or other realms of literature that discuss how to protect environmental assets. In fact, two different and opposite approaches are being discussed. The literature on soft target hardening recommends hardening to the capacity of not being transparent, so that the terrorist will not be able to view, surveil, or select the target. The CPTED principles, however, view aesthetics and transparency as crucial elements for the environmental user to surveil and detect the threat.

Atlas and DiGregorio reference federal regulations for blast protection but do not include any homeland security directives, such as the Homeland Security Presidential Directive 19 (HSPD-19), or challenges in combating terrorist use of explosives, such as the National Science and Technology Council—Domestic Improvised Explosive Devices Subcommittee, December 2008.[109] In other words, the book provides extensive knowledge and principles for CPTED but does not provide challenges for explosive protection in critical infrastructure, as demonstrated in other literature. Furthermore, while the reader can infer that the authors are making an argument to protect innocent civilians from external threats and crime, the discussion of soft targets or crowds is not addressed. Additionally, the airport is categorized as critical infrastructure, but it is not their main focus.

Experts in the aviation industry, such as Price, Forrest, Seidenstat, and Splane, provide several recommendations to improve terminal spaces and airport infrastructure from terrorist attacks and active shooters.[110] These recommendations include the use of

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[108] Randall I. Atlas and Tony DiGregorio, "Designing for Explosive Resistance," in *21st Century Security and CPTED, Designing for Critical Infrastructure Protection and Crime Prevention*, ed. Randall I. Atlas (Boca Raton, FL: Taylor & Francis Group, 2008), https://libsearch.nps.edu/vufind/Record/1124538.

[109] White House, *Combating Terrorist Use of Explosives in the United States, Homeland Security Presidential Directive 19* (Washington, DC: White House, 2007), https://fas.org/irp/offdocs/nspd/hspd-19.pdf; National Science and Technology Council-Domestic Improvised Explosive Devices Subcommittee, *Research Challenges in Combating Terrorist Use of Explosives in the United States* (Washington, DC: National Science and Technology Council-Domestic Improvised Explosive Devices Subcommittee, 2008), http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA505299.

[110] Price and Forrest, *Practical Aviation Security*; Paul Seidenstat and Francis X. Splane, *Protecting Airline Passengers in the Age of Terrorism* (Santa Barbara, CA: ABC-CLIO, 2009).

personnel, such as law enforcement, canine handlers for explosive detection, and uniformed transportation security officers (TSOs). The aviation industry does not encompass the professional expertise of CPTED to provide tangible and applicable infrastructure terrorism countermeasures. On the other hand, engineers and architects from the field of CPTED do not believe that the measures, as recommended by the aviation industry, provide sufficient protection. In other words, CPTED proponents believe that the environment can be designed to decrease threats of crime, whereas proponents in the aviation industry believe personnel assets and force protection are required. These two fields diverge in their beliefs of what essential resources are required to protect the soft target.

3. Research Design

The purpose of the research is to conduct comparative case study analysis to determine how environmental designs failed and where they successfully restricted an attack. The objective is to apply analytic generalization to airport environments.[111]

a. Selection

Three illustrative cases of airport attacks are included.[112] These cases include Brussels (2016), Los Angeles (2013), and Glasgow (2007). Each represents deliberate attacks by adversaries. The Brussels case involved terrorist suicide bombers, the Los Angeles case involved an active shooter, and the Glasgow case involved a vehicle borne improvised explosive device (VBIED). The attacks in all these cases were aimed at killing masses of people. The environment layout and the number of casualties in each case were different. The method and cases were selected because they provide qualitative operational links to how environmental designs influence the adversaries' choices.

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[111] Robert Yin, *Case Studies Research, Design, and Methods* (London: Sage, 2003), 33. See Yin for an explanation of illustrative case studies.

[112] Yin, 30–35. See Yin for an explanation of illustrative case studies.

b. Data Sources and Mode of Analysis

The independent variable in this research is the airport environment design and the dependent variable is human attack perception. The sources of data derive from the literature, agency reports, and airport records. The research analysis criteria consist of airport terminal layouts, structural facility for crowd protection, and before and after event pictures. The mode of analysis includes an evaluation of the attack location, method, and impact. The perceptions of opportunistic attack and alternative measures are described in each scenario. The units of analysis are the number of individuals (non-attackers) killed, placed in the context of the capacity of the airport terminal.

c. Limits

The boundaries of the cases are limited to the airport environment and may not be transferable to other areas or environments. The human perception of the target selection (crowds) is also limited to the airport construct.

d. Output

The analysis of the cases studies should reveal how specific measures of CPTED principles and human behavior play a role in thwarting attacks and saving lives, which are accomplished through before and after scenario demonstrations. The output of the case study includes recommendations for environmental design models that protect soft targets that may include elements to address human perception in deterring attacks toward soft targets. The recommendations are intended for airport designers, airport security authorities, and policy makers to be able to secure the traveling public, protect the airport infrastructure, and the overall airline industry better.

C. CONCLUSION

The literature review for the protection of soft targets from adversarial attacks revealed that islands of information are available that focus on how to deter terrorism, prevent crime, or protect soft targets. The literature on soft target hardening and deterrence theory intersects in several areas, whereas CPTED principles diverge. The literature from the aviation sector, on the other hand, is primarily focused on preventing

explosives and dangerous weapons from entering aircraft. The recent literature in soft target hardening provides valuable research for the protection of crowds and innocent civilians. This thesis attempts to bridge these concepts and schools of thought to provide plausible recommendations for the protection of soft targets and STS in the aviation transportation system.

II. POLICY APPROACHES TO AVIATION TRANSPORTATION SECURITY IN EUROPE AND THE UNITED STATES

The comparative analysis of counter-terrorism strategies between the United States and the European Union offers a lens to best practices for crowd protection, airport infrastructure, and aviation security. This chapter delivers analysis of U.S. and European policies that govern aviation security and soft targets and crowd protection in the airport. Specifically, the following government agencies are compared: the DHS TSA; the UK Department for Transport (DfT); the Belgian Civil Aviation Authority (BCAA); and the Belgian Federal Public Service Mobility and Transport department. The roles of airport boards and their responsibly for crowd protection is also addressed. Europe has been tackling terrorism for many years and their system and approach methods provide valuable insight for the United States. The question is how do the policies of these countries address protecting crowds in the public spaces of the airport?

The TSA and airport boards provide regulatory policies and strategic implementation, respectively, to mitigate threats toward aviation and to protect the airport infrastructure. The ATSA of November 2001, which created the TSA, provides federal security directors (FSDs) with flexible authority to administer and regulate aviation security.[113] In March 2003, the TSA moved from its initial signatory of the Department of Transportation to the DHS and is predominantly responsible for the administration of transportation security in the United States; whereas, the airport boards are responsible for executing the security practices. In other words, the TSA may fine airports if they do not comply with security practices but airports are responsible for taking action to ensure security practices are in place.

The TSA has a limited area of control and operation in the physical environment of the airport. Its main mission objective is to detect and deter aviation threats through screening passengers, baggage, and cargo. It also directs industry compliance with the

[113] "S. 1447 (107th): Aviation and Transportation Security Act," GovTrack, accessed August 20, 2017, https://www.govtrack.us/congress/bills/107/s1447/text; National Commission of Terrorist Attacks upon the United States, *The 9/11 Commission Report.*

federal code of regulations. The Office of Infrastructure Protection (IP) is another government entity that provides guidance in protecting critical infrastructure; however, its direct role in airports is limited, as it does not provide direct oversight and regulation requirements to mitigate risk in the airport public areas. Its primary role is to establish guidance documents for critical infrastructure and industry leaders.

The International Civil Aviation Organization (ICAO) and the European Commission (EC) of the EU are the lead authorities for aviation transportation and security in Europe.[114] The ICAO was established after the Chicago Convention (Convention on International Civil Aviation) in 1944 and is a specialized agency of the United Nations.[115] Due to the fact that both the United Kingdom and Belgium are EU member states, the European Union's overarching aviation transportation policies are examined in relation to STS. Each European country must first adhere to these common standards whilst implementing its own national policies. Hence, European aviation security meets stricter standards because they have to adhere to domestic, national, international, and continental standards. The European Aviation Safety Program (EASP) collectively integrates the EU rules for uniform safety and security at the EU level, and it ensures all member states comply with these polices.[116] Although the United Kingdom has voted to leave the European Union through the BREXIT agreements, ICAO standards for aviation security will remain consistent and "it may still be subject to most or all European legislation affecting the aviation sector."[117]

Terrorism attacks have historically occurred at a greater frequency in Europe; for example, the Irish Republican Army (IRA) was an active terrorist group in the United Kingdom from 1960 to 2005. With the increasing number of terrorist attacks in Europe,

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[114] "Regulation (EC) No 216/2008," European Aviation Safety Agency, 2008, https://www.easa.europa.eu/document-library/regulations/regulation-ec-no-2162008; "About ICAO," ICAO, accessed August 21, 2017, https://www.icao.int/about-icao/Pages/default.aspx.

[115] ICAO, "About ICAO."

[116] Belgian Civil Aviation Authority, Federal Public Service Mobility and Transport, and Belgium Air Accident Investigation Unit, "*Belgium Aviation Safety Programme*," version 1.0 (Brussels: Federal Public Service Mobility and Transport, 2015), 3, https://mobilit.belgium.be/sites/default/files/downloads/Belgium%20Aviation%20Safety%20Programme_v1.0.pdf.

[117] IATA, *The Impact of "BREXIT" on UK Air Transport* (Montreal, Canada: IATA, 2016), 5, http://www.iata.org/publications/economic-briefings/impact-of-brexit.pdf.

the ICAO and the Europe Union recognized that changes need to be implemented to protect soft targets. The United Nation's *Thirteenth Symposium of the ICAO Traveller Identification Programme* of October 2017 is a good example of how the ICAO has begun to address soft target concerns. The Counter-Terrorism Committee Executive Directorate (ICAO Headquarters) includes a risk management framework to support counter-terrorism objectives via the passenger air travel cycle and enhanced border management.[118] It recognizes the concerns over STS in airport landsides.

In all three countries (the United States, United Kingdom, and Belgium), the policies that regulate and secure aviation transportation are governed by a similar system (*secure* side versus *non-secure* side/ or *airside* versus *landside*); as discussed in Chapter I. The proceeding discussion examines each country's policy approach in protecting soft targets in the airport environment and draws on applicable techniques for U.S. strategies. The purpose is to explore evolving polices in Europe and identify effective methods that may be transferred to the United States.

A. THE UNITED KINGDOM, BELGIUM, AND THE UNITED STATES

A fundamental factor for aviation security is how each government approaches the issue of *crowd protection*. The United Kingdom integrates policies directly from the Home Office's CONTEST into all aspects of government and social life in the United Kingdom (see Appendix B). For comparison purposes, the authority of the UK's Home Office stands at a higher government echelon than the TSA; hence, giving it added power in how the policies are executed. The United Kingdom's CONTEST policy was specifically created to protect crowded spaces; whereas in the United States and Belgium, the protection of crowded spaces is delineated through the authorities of partnering agencies, such as the airports and airline industry, as well as the federal and local police.

The DHS-TSA has a principal role in securing aviation transportation in the United States. The United Kingdom's Home Office "lead department" role, on the other hand, is a cross-sectional, inter-agency collaborative model where the CONTEST

[118] "Thirteenth Symposium on the ICAO Traveller Identification Programme," ICAO, slide 4, October 24–26, 2017, https://www.icao.int/Meetings/TRIP-Symposium-2017/Presentations/SEESMAA.pdf#search=soft%20targets.

strategy is assimilated in each agency, department, community, and local policing practice. In Belgium, homeland security is administered from the Deputy Prime Minister of Security and the Interior, and transportation through the Minister of Mobility.[119] Although the layers of the Belgium government are much smaller in scale to that of the United States, separate ministers in essence govern the policies for homeland security and transport. The key distinction in crowd protection strategies between the United States and the European Union (United Kingdom and Belgium) is that the European Union transcends the government's role by placing a substantial emphasis on strengthening public-private partnerships in counter-terrorism. These approaches are continuing to develop in the United States and Belgium and have not fully matured to the level employed in the United Kingdom.

1. U.S. Policies

Since 9/11, the TSA continues to enhance and secure aviation transportation. Unique to other federal government agencies, the TSA performs two roles, 1) *regulates* the policies enacted in ATSA through the Code of Federal Regulations (49 CFR Part 1544), and 2) *executes* the physical screening of passengers and baggage for air travel.[120] Therefore, the agency both implements and regulates the CFRs, which has spurred debate about whether the TSA is the checker or the doer of the policy. TSA's dual role also raises concern about "which entity is accountable for protecting areas *other than checkpoints*" (my emphasis).[121] Additionally, it confounds the issue of who is to protect the traveling public in the terminal spaces and passenger queuing areas (i.e., soft targets). Presently, this responsibility lies with the airport authorities in the United States;

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[119] "Ministers, FPS Chancellery of the Prime Minister," Belgian Federal Government, accessed August 21, 2017, http://www.federal-government.be/en; "Ministre de la Mobilité, chargé de Belgocontrol et de la Société nationale des chemins de fer belges," François Bellot, accessed August 21, 2017, http://bellot.belgium.be/fr; "Deputy Prime Minister and Minister of Security and Home Affairs," Jan Jambon, accessed August 21, 2017, http://jambon.belgium.be/en/.

[120] Cornell Law School, "49 CFR Part 1544—Aircraft Operator Security: Air Carriers and Commercial Operators," Legal Information Institute, accessed August 21, 2017, https://www.law.cornell.edu/cfr/text/49/part-1544; *Statement of John Roth, Inspector General, Department of Homeland Security before the Committee on Oversight and Government Reform U.S. House of Representatives Concerning TSA: Security Gaps*, House of Representatives, 115th Cong., 2015, 10, https://oversight.house.gov/wp-content/uploads/2015/11/11-3-2015-Committee-Hearing-on-TSA-Roth-DHS-OIG-Testimony.pdf.

[121] H., *Statement of John Roth*, 10–11.

however, passengers in a TSA waiting queue may not realize this is the case.[122] The issue is that, unlike the UK's CONTEST policy that addresses crowded spaces in all realms of society, the policies of the U.S. government do not. The CFRs for aviation security and ATSA do not address protecting crowded spaces, and these areas of the airport are not under the direct executing authority of TSA.

2. U.S. Response to STS

STS in the United States remains a challenge because the policies that govern aviation security do not incorporate crowd protection. Public space security (non-sterile area) at U.S. airports is not mandated by ATSA, nor regulated by the TSA. A video by Bloomberg provides a good description of this airside-landside challenge in security. Chris Jasper attests to the fact that although airport security screening does occur, "large areas of the airport [are] essentially unprotected."[123] What he is referring to is that security screening authorities check for dangerous weapons at the checkpoints, but the other areas of the airport remain unchecked. The TSA FSDs may provide guidance and recommendation to the airports and airline industry, but it is ultimately up to the airports to implement the security measures for crowd protection.

Another challenge the United States faces in protecting soft targets is standardizing policing and law enforcement among all the airports nationwide. Copious policing agencies, authorities, and cities have jurisdiction over the airport, or parts of it. Airports that have to coordinate with multiple police departments and law enforcement agencies (both local and federal) confound the ability to harness efficient counter-terrorism measures. Multiple issues arise, such as lack of efficient communication, duplication of effort, complex coordination of emergency management, and different systematic approaches to one entity, i.e., the airport environment. The United Kingdom, on the other hand, has a national and unified police department whose sole responsibility

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[122] "Public Law 107-71 Aviation and Transportation Security Act," U.S. Government Publishing Office, accessed August 21, 2017, https://www.gpo.gov/fdsys/pkg/PLAW-107publ71/content-detail.html. See the ATSA law regarding "secured areas."

[123] "Rethinking Airport Security after the Brussels Attacks," YouTube video, 1:10, posted by Bloomberg, March 29, 2019, https://www.youtube.com/watch?v=vefK5nVK1gU.

is to police the airports. This type of system results in specialized policing with a common language and understanding of the aviation structure and network; hence, offering efficient communication and interoperability.

3. UK Policies

In the United Kingdom, the European Commission's Implementing Regulation (EC) 2015/1998 of November 2015 governs the basic standards for aviation security.[124] The United Kingdom's DfT administers this comprehensive law through its separate unit of the Transport Security and Contingencies Directorate (TRANSEC).[125] The TRANSEC is a regulating entity, like the TSA, which enforces security measures in road, rail, and air travel. Its legal role derives from the Aviation Security Act of 1982, the Aviation and Maritime Security Act of 1990, the Channel Tunnel Security Order of 1994, along with the EU regulations.

Since the 9/11 attacks, the TRANSEC has "become increasingly embedded in the counterterrorism community, and its work is very much a part of the Government's overall counterterrorism strategy (CONTEST), which was revised and re-launched in March 2009."[126] The four main CONTEST principles are *Prevent, Pursue, Protect* and *Prepare* (see Appendix B).[127] TRANSEC is not responsible for executing the screening of passengers and baggage in airports, whereas in the United States, the TSA provides the majority of screening at security checkpoints in commercial airports.[128] In the United

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[124] "Commission Implementing Regulation (EU) 2015/1998 of 5 November 2015 Laying down Detailed Measures for the Implementation of the Common Basic Standards on Aviation Security (Text with EEA Relevance)," EUR-Lex, November 14, 2015, http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32015R1998; Current law repealed Regulation (EC) No 2320/2002.

[125] Department of Transport, *TRANSEC Annual Report April 2008–March 2009* (London: Department of Transport, 2009), 8, http://webarchive.nationalarchives.gov.uk/+/http:/www.dft.gov.uk/pgr/security/about/transecannualreports/transecannualreport0708.pdf.

[126] Department of Transport, 8.

[127] Department of Transport, 9.

[128] In 2016, United States had 5,136 public airports and 22 airports were contracted to private security companies through the Screening Partnership program. "Screening Partnership Program," Transportation Security Administration, accessed February 12, 2018, https://www.tsa.gov/for-industry/screening-partnerships; "Table 1–3: Number of U.S. Airports(a)," Bureau of Transportation Statistics, accessed February 12, 2018, https://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_01_03.html.

Kingdom, all screening is performed by private security agencies. Although the argument about which is better (hiring private security screening companies or having government agencies conduct this function) is beyond the scope of this thesis; an important point to consider is that that United States and European Union significantly differ in how they execute this function.

TRANSEC has a direct relationship with the government and conjoins between the Home Office Counter-Terrorism Programme and DfT, unlike the TSA, which is a sub-agency of the DHS. Its position within the UK government gives it suitable leverage to implement and change policies because it is closely *embedded* in the UK government's counter-terrorism strategy; whereas the TSA serves a transient role in receiving and giving counter-terrorism information to other federal and state law enforcement entities. In contrast, the TRANSEC complements the activities of the police, intelligence agencies, and security stakeholders because they work conjointly with the Centre for the Protection of National Infrastructure (CPNI) to mitigate soft target vulnerabilities.[129] Although the TSA may perform some of these activities, due to the fact that ATSA gives FSDs substantial flexibility in implementing policies and procedures [e.g., via MOUs with the airports and police], they vary from one airport to another. Thus, the nation does not have just one systematic approach. An example is how the TSA works in partnership with the local police's canine units to patrol terminal spaces. In each airport for example, the canine unit's AOR is contingent upon a MOU between the police and the TSA. Hence, no universal method is implemented in the way police departments function. Operational relationships vary between the two entities across the nation's airports.

The UK's system of aviation security standardizes police and transportation security practices at airports. The DfT consultation paper on *Airport Policing, Funding, and Security Planning* "sets out the intention that <u>all</u> UK airport operators should pay for agreed levels of dedicated policing at their airports" (author's emphasis).[130] Again, this policing is different from that implemented at U.S. airports, which is not standardized.

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[129] Department of Transport, *TRANSEC Annual Report April 2008–March 2009*, 4, 10, 14.

[130] Department of Transport, *Airport Policing, Funding, and Security Planning, A Consultation Paper* (London: Home Office, 2008), 5, http://library.college.police.uk/docs/dft/airportpolicing-consultationpaper.pdf.

The UK's Transport Security Bill sets out this objective by additionally endorsing the concept of airports as "communities" approach.[131] The rationale to this approach was based on Sir John Wheeler's (Secretary of State for Transport and Home Secretary) 2002 review and the 2006 Independent Review of Airport Policing that identified several key concerns at UK airports; such as the lack of a shared strategic vision, lack of open communication and relationships among airport stakeholders, delayed risk assessments, misunderstanding of airport security roles for individuals, omission of airport policing, and a lack of a national vision to meet the threat.[132]

After the report was released, the Multi-Agency Threat and Risk Assessment (MATRA) was created to provide for a uniformed police approach across UK airports. This approach resulted from the Sir John Wheeler independent report on the assessment of airport security and the terrorism threat.[133] The basis of the policy was to implement collective partnership and accountability for aviation security at *all* airports. Although the TSA also regulates ASPs at each U.S. commercial airport, the United Kingdom's MATRA aimed to produce a cohesive plan to integrate the entities of the airport, airlines, police, government agencies, and other important stakeholders; hence, all the key players of aviation security were brought together to develop a common approach.

In 2007, the United Kingdom's Prime Minister Tony Blair requested Lord West "to conduct a review of how crowded places, transport infrastructure and critical national infrastructure can best be protected from terrorist attack."[134] The request demonstrates the United Kingdom's deliberate and systematic method to develop policies that protect crowds in public places. In 2010, MATRA was transformed into a two-part airport security-planning framework, the RAG and the SEG, with a concentration in the CONTEST policy.[135] The RAG functions on a *practitioner* level by bringing together

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[131] Department of Transport, 8.

[132] Department of Transport, 7–8.

[133] John Wheeler, *Airport Security Report* (United Kingdom: Home Office, 2002), http://webarchive.nationalarchives.gov.uk/+/http:/www.dft.gov.uk/pgr/security/aviation/airport/airportsecurityreport.pdf.

[134] Department of Transport, *TRANSEC Annual Report April 2008–March 2009*, 13.

[135] Department of Transport, *Airport Security Planning Quick Guide* (London: Home Office, 2010), 5, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/11516/guide.pdf.

airport managers and the local chief of police; and its purpose is to conduct airport risk reports. The SEG functions on a *senior executive level* by bringing together responsible individuals who have the authority to implement security measures. The risk report establishes the police services agreement to determine the amount of airport policing required and how much the airport operator will pay.[136] These groups are important because they assess risk and provide valuable information about an airport's security program. This comprehensive systems approach attempts to address the entire threat picture based on the government policies discussed. Forming such groups and systems would significantly improve the airport threat preparedness posture in the United States.

4. United Kingdom's Response to STS

The United Kingdom's seamless approach to policing, partnering with stakeholders, and ASP standardization ensures the traveling public is protected from aviation terrorism threats. The CONTEST strategy is holistic and community oriented because it brings together the parliamentary and local government on a joint counter-terrorism objective. Additionally, it recognizes the impact of the threat toward soft targets and it specifically addresses how to protect crowded areas and instill resiliency from attack. For example, the TRANSEC has four strategies to reduce risk and enhance resilience. These strategies include *reduce risk*, *minimize impact*, *enhance resilience*, and *retain confidence*.[137] It points out that "retaining confidence and minimizing impact, have always been an important factor in TRANSEC's work… [and] we should give them more focused attention over the coming years in order to provide a robust 'reality check' on proposed security measures to better understand and measure the impact of our programmes."[138] The UK *resiliency* strategy is one aspect of aviation transportation security that would prove useful in the United States toward the protection of soft targets.

According to the TRANSEC's annual report, the national aviation security programme (NASP) "is the most mature" of the rest of United Kingdom's transport

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[136] Department of Transport, 5.

[137] Department of Transport, *TRANSEC Annual Report April 2008–March 2009*, 9.

[138] Department of Transport, 11.

industry security programs because it has been in the business since the 1970s.[139] The organization has gained significant experience since the terrorist events of the IRA, airline bombing over Lockerbie, and other natural disasters. The goals of *resiliency* and *minimizing impact* from a terrorist event present a plan to address several key social and aviation security components. Beginning in 2011, the TSA implemented a RBS approach; however, its "20 layers of security" do not encompass strategies to enhance *resilience* or *minimize impact*.[140] Its main objective is in fact to *detect* and *deter* a threat to an airliner to prevent another airline hijacking.[141] The TSA layers do not specifically incorporate protection to soft targets in the airport environment. This point is important because threats to aviation security are evolving to include attacks on crowds.

The DHS -IP offers national programs and policies to guide critical infrastructure protection, security, and resiliency, and its platform closely resembles those of DfT and the TRANSEC.[142] However, the DHS IP does not have any enforcement or regulatory authority over airports and its role is minimal. Its main vision and mission is to "secure a resilient critical infrastructure across the Nation achieved through sound risk management, collaboration, information sharing, innovation, effective program management, and a highly skilled workforce" through a collaborative effort between the public and private sector.[143] Although it has great tools for this purpose, no evidence has been presented that it provides protection for crowded spaces at airports. In fact, the first joint meeting between the TSA and DHS-IP occurred only recently in mid-September of 2016 to develop the *Public Area Security National Framework* as a response to the

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[139] Department of Transport, 13.

[140] "TSA Layered of Security," Aviation Knowledge, accessed August 21, 2017, http://aviation knowledge.wikidot.com/aviation:security-layers; "TSA's Successes and Challenges of Risk-Based Security," Transportation Security Administration, https://www.tsa.gov/news/testimony/2012/03/26/tsas-successes-and-challenges-risk-based-security.

[141] *Statement of Peter Neffenger, Administrator, Transportation Security Administration U.S. Department of Homeland Security before the United States House of Representatives Committee on Oversight and Government Reform*, House of Representatives, 115th Cong., 3, 2015, https://oversight. house.gov/wp-content/uploads/2015/11/11-3-2015-Committee-Hearing-on-TSA-Neffenger-TSA-Testim ony.pdf.

[142] "Office of Infrastructure Protection," U.S. Department of Homeland Security, accessed August 24, 2017, https://www.dhs.gov/office-infrastructure-protection.

[143] U.S. Department of Homeland Security, Vision and Mission, para 2.

Brussels attacks.[144] The coordinated effort by these entities shows a positive step forward, although not as robust as the UK approach. The lessons learned from the United Kingdom and CONTEST can provide a significant contribution to the policies enacted in the United States.

5. Belgian Policies

Belgium's aviation policy framework is governed by the Belgian Aviation Act of 1937, the Royal Decree of 1954, and the EU Basic Regulation (EC) No 216/2008 and Regulation (EC) No 139/2014, also known as the "EASA Regulations."[145] The BCAA was designated by the Ministerial Decree of January 2009 as the Belgian component authority for EASA regulations, and is part of the Federal Public Service Mobility and Transport.[146] The BCAA develops and maintains the Belgium aviation safety programme (BASP) in accordance with ICAO standards. Thus, Belgium considers both the EASP and BASP policies in implementing national aviation safety.[147] Belgium is home to the EU headquarters, and as a member state, it also adheres to all European aviation system rulemaking and oversight activities.

The Belgium Federal Public Service Mobility and Transport is divided into four directorates (mobility and traffic safety, road, maritime transport, and aviation) and is responsible for administering transportation security and overseeing several government entities that include national railway and the Brussels Airport Company.[148] The Brussels

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[144] "Public Area Security Summits," Transportation Security Administration, May 2017, https://www.tsa.gov/for-industry/public-area-security-summits.

[145] Federal Public Service Mobility and Transport, Belgian Civil Aviation Authority, *Belgium Aviation Safety Programme* (Brussels: Belgian Civil Aviation Authority, 2015), 4, https://mobilit.belgium.be/sites/default/files/downloads/Belgium%20Aviation%20Safety%20Programme_v1.0.pdf; "Air, Aviation Security," European Commission Mobility and Transport, December 30, 2017, https://ec.europa.eu/transport/modes/air/security_en; "European EASA Airport Certificate for Brussels Airport Confirms High Level of Safety in Infrastructure and Operational Processes," Brussels Airport, August 2017, https://www.brusselsairport.be/pressroom/european-easa-airport-certificate-for-brussels-airport/.

[146] Federal Public Service Mobility and Transport, Belgian Civil Aviation Authority, *Belgium Aviation Safety Programme*, 4.

[147] Federal Public Service Mobility and Transport, Belgian Civil Aviation Authority, 3–4; EASA, "Legal and Regulatory Framework," accessed August 21, 2017, https://www.easa.europa.eu/easa-and-you/safety-management/accident-and-incident-investigation-support/legal-and-regulatory-framework.

[148] Wikipedia, s.v. "federal public service mobility and transport," last edited January 20, 2018, https://en.wikipedia.org/wiki/Federal_Public_Service_Mobility_and_Transport.

Airport Company develops and implements security measures at the Zaventem international airport, including hiring contracting services to conduct passenger screening. On October 24, 2017, the Brussels Airport Company awarded and updated contracts to G4S and ICTS.[149] Similar to the United Kingdom, these companies are contracted privately. The role of EU versus U.S. transportation agencies demonstrates a key difference between the two. EU transportation security agencies establish different relationships with their stakeholders. In other words, they do not hold a dual security role, such as the DHS-TSA.

6. Belgium's Response to STS

The terrorist attacks of March 22, 2016 in Brussels caused the Belgium government and the European Union to consider alternative methods for soft target protection. In May 2016, the Airports Council International (ACI) released a *Position Paper* that identified several key aspects for airport landside security. One main conclusion was that "any measures should be seen in the context that airport landside security measures are not aviation security measures but must form part of wider scope of public spaces security measures, aimed at protecting a rage of urban soft targets," along the myriad modes of transportation.[150] It also concluded that these measures should be considered at the national and local level, not the EU level. Additionally, they agreed that intelligence sharing and the use of "high visibility deterrence measures," such as canines, law enforcement, and behavior detection should be implemented.[151] The group did not propose any changes to airport design measures, with the exception of removing screening at the entrance of the airport. This notion was seconded by the Director of the ACI, Oliver Jankovec, who requested that the Ministers of the Belgium Federal Public

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[149] "Following a European Tender, Brussels Airport Chooses G4S and ICTS as Its Security Partner for 2018," Brussels Airport, October 24, 2017, https://www.brusselsairport.be/pressroom/following-a-europe an-tender-brussels-airport-chooses-g4s-and-icts-as-its-security-partners-for-2018/.

[150] Aviation Security Committee, *Airport Landside Security, Position Paper* (Bruxelles, Belgium: Airports Council International Europe, 2016), 3, https://www.aci-europe.org/policy/position-papers.html?view=group&group=1&id=4.

[151] Aviation Security Committee, 3.

Service Mobility and Transport remove the screening of passengers at the terminal entries and employ strategies, such as those used by the Israeli authorities.[152]

In October 2017, the EC released the *Action Plan to Support the Protection of Public Spaces* to "set out measures to provide guidance and support to Member States at national, regional, and local level in protecting public spaces."[153] By injecting 18.5 million euros, the EC aims to have member states develop innovative infrastructure for STS and instill better coordination between first responders. More importantly, by October 2018, an additional 100 million euros will be supplemented for the urban innovative actions (UIA). The UIA is a European Regional Development Fund that will provide the same basic principles as CPTED for "ensuring the physical resistance of buildings, the physical protection of crowded places and promoting security by design."[154] The goal is to increase STS by designing innovative solutions to public spaces; and the EC has taken it a step further by launching a request for proposals and public interest into the project. By taking this action, the EC intends to increase awareness of security in public spaces and calls on EU member states to support the initiative.[155]

EU member states' experience and approach to STS are distinctive and the EC's plan is to provide a forum for expertise and best practices, including assisting countries to develop policies.[156] A key to this support is the *EU Policy Group on Soft Target Protection*, which will bring together national policy-makers for a practitioner's and operator's forum. This forum will include conducting law enforcement joint exercises for soft target attack preparedness, sharing manuals and lessons learned, and establishing

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[152] "Letter 27 April 2016 (Ministers Jan Jambon and François Bellot—Landside Security Measures," Airports Council International Europe, April 27, 2016, https://www.aci-europe.org/policy/position-papers.html?view=group&group=1&id=4.

[153] "Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee of the Regions, Action Plan to Support the Protection of Public Spaces," Eur-Lex, 2, October 18, 2017, http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1510624293824&uri=CELEX:52017DC0612.

[154] Eur-Lex, 3.

[155] Eur-Lex, 4.

[156] Eur-Lex, 5.

global partnerships between the European Union and United States for enhanced explosives detection. By developing common guidance, the European Union hopes to protect public spaces, such as airport landside areas.

Similar to Coaffee's discussion of United Kingdom's CONTEST strategy and building resilient space, the EC also believes that "security by design" should begin in the early stages of development.[157] It has developed an EU soft target site assessment tool to assess public space vulnerabilities. One of the objectives for the third quarter of 2018 is to provide airport landside STS by focusing on passenger flows.

The EC, similar to the UK government policies, also seeks to engage the private sector and build on the public-private partnership to protect soft targets. The strategy holds that building strong public-private relationships are productive in counter-terrorism measures because open communication occurs between the two actors, thereby increasing policy adherence and engagement toward recognizing and annihilating terrorism. The aim is to involve mayors, local and regional businesses, and other relevant stakeholders that include facilitating funding opportunities and involving key actors to stimulate public awareness. The EC will conduct a review and assessment of the action plan by the end of 2018.[158]

B. COMPARATIVE ANALYSIS OF UK, BELGIUM, AND U.S. POLICIES

It is evident from the strategies of the EC and the United Kingdom's Home Office that policies toward crowded spaces in Europe are more robust. In fact, as part of the CONTEST *Protect* objective, the intention is to "increase the resilience of the UK's infrastructure and improve protective security for crowded places," which has been accomplished since the policies' enactment.[159] This type of policy does not exist in the United States. The CONTEST strategy in the United Kingdom has been very successful

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[157] Coaffee et al., "Resilient Design," 107. See the explanation of Coaffee in the Chapter 1; Eur-Lex, "Communication from the Commission to the European Parliament," 6.

[158] Eur-Lex, 8.

[159] Controller of Her Majesty's Stationery Office, *CONTEST: The United Kingdom's Strategy for Countering Terrorism* (London: e Stationery Office Limited, 2011), https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/97995/strategy-contest.pdf.

in integrating these components. Although classified, copious terror plots have been averted (the transatlantic aircraft liquid bombing plot is one example).[160] Furthermore, the strategy recognizes that "aviation security must be an international endeavor or it will not succeed" and that private sector partners are pivotal to its success.[161] So how effective or ineffective is this strategy and how much of it can be implemented in the United States? This question is examined in the following section.

1. U.S. Policy Approach to STS

To take a systematic method to protect crowds in public spaces of airports, the United States would have to begin with updating its policies regarding transportation security and its mission. One method is to update ATSA and increase the TSA's mandate and footprint. In the airport environment, it would require closer relationships with the police force and stakeholders. For example, the TSA's detect goal aligns closely with the *Protect* goal, and *deter* with *Pursue* (see Appendix B). However, the TSA cannot "*Prevent*: stop people from becoming terrorists or supporting terrorism," nor can it "*Prepare*: to mitigate the impact of a terrorist attack" according to the current law.[162] The two latter responsibilities belong to different entities of the U.S. government and are not under the auspice of the DHS, such as the Central Intelligence Agency (CIA), Federal Bureau of Investigation (FBI), and state and local police. Hence, polices and partnerships between these entities would need to consider soft targets, specifically.

Mitigating a threat impact and ensuring resilience is the airport's responsibility and the U.S. government does not play a direct role in it. For example, the *Recommended Security Guidelines for Airport Planning, Design and Construction*, released in 2017, "represents the fifth iteration of *guidance* for the airport planning and design community, first issued by the FAA in 1996 and 2001, continued by the TSA in 2006 and 2011, and

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[160] Seth G. Jones, *Hunting in the Shadows, The Pursuit of Al Qa'ida since 9/11* (New York: W.W. Norton & Company, Inc., 2012), 20.

[161] Controller of Her Majesty's Stationery Office, *CONTEST*, 12–13.

[162] Controller of Her Majesty's Stationery Office, 6.

now provided by National Safe Skies Alliance in 2017" (my emphasis).[163] This document demonstrates that no one distinct or coherent body manages the airport's security infrastructure for soft target protection. The document attests, "the guidelines are not government regulations and requirements; they are a compendium of real-world experience and best practices."[164] The guidelines are comprehensive and thoroughly researched and provide a great resource for airport blast protection, infrastructure risk mitigation, and a compendium of technical expertise. For example, design strategies are explained for improving airport roadways, parking facilities, blast resistant façades, CCTV, structural columns, vehicle barriers, and vehicle inspection stations. Crowd protection is not the core emphasis of the document; however, the threat vulnerability to public non-sterile areas is recognized.

The document is a reminder that, "normally, the airport operator will retain responsibility for enforcement, monitoring of alarms, requests for criminal investigations, and fire, safety, and health inspections."[165] This issue becomes somewhat complex because the TSA must still approve and regulate ASPs (see also 49 CFR 1542).[166] However, the areas of the ASP that the TSA regulates are directly linked to ATSA, which does not discuss protecting crowds, mitigating impact, or ensuring resilience to attack. Without changing the law, transferring the UK governments' CONTEST or EC strategies into the United States would prove ineffective, as it would require a change in mission strategy and support from Congress.

The U.S. government has initiated some positive steps toward securing soft targets in the airport. As a result of the Brussels attack, Congress passed the FAA Extension, Safety, and Security Act in July 2016. Under Title III, Aviation Security, Section 3601, this public law included the language of "non-secure" and "non-sterile"

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[163] "Recommended Security Guidelines for Airport Planning, Design, and Construction," National Safe Skies Alliance, Inc., xvii, April 2017, http://www.transecure.us/recommended-security-guidelines-for-airport-planning-design-and-construction/.

[164] National Safe Skies Alliance, Inc., xvii.

[165] National Safe Skies Alliance, Inc., 14.

[166] Cornell Law School, "49 CFR 1542.101 General Requirements," accessed August 24, 2017, https://www.law.cornell.edu/cfr/text/49/1542.101.

areas and granted the TSA the authority to re-deploy visible intermodal prevention and response (VIPER) teams no non-sterile areas.[167] These teams surveil the physical environment for anomalies and threats. The bill also amended the Homeland Security Act of 2002 by granting funds to local, state, and tribal governments to implement "training exercises to enhance preparedness for and response to mass casualty and active shooter incidents and security events at public locations, including airports and mass transit systems."[168] Additionally, it provides grants for enhanced security and preparedness of non-secure areas in airports and surface transportation. The intention of the law is to provide government funds to increase security measures in public spaces of transportation systems.

A progressive step toward protecting soft targets was also taken by the TSA and DHS-IP, as mentioned earlier, in the *Public Area Security National Framework* of 2017.[169] This document provides recommendations for improving information sharing, attack prevention, infrastructure, and public protection. In essence, it initiated a national interchange dialogue for a united effort to safeguard public spaces for aviation security. As described in the document, the aim of these agencies is to continue to move forward in this interexchange of ideas and collaboration, both nationally and internationally.

The TSA has taken another positive step forward by delivering the "Intermodal Security Training and Exercise Program (I-STEP)."[170] This federal program, known as I-STEP, supports several modes of transportation by providing training, exercise, and security planning tools to reduce risk to transportation networks.[171] The objective of the program is to partner with transportation operators and businesses to shape national transportation security policy via the lessons learned from the I-STEP exercises.

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[167] "H.R.636-FAA Extension, Safety, and Security Act of 2016," Congress.Gov, accessed January 20, 2017, https://www.congress.gov/bill/114th-congress/house-bill/636/text.

[168] Congress.Gov, Section 3602.

[169] Transportation Security Administration, "Public Area Security Summits."

[170] "Intermodal Security Training and Exercise Program," Transportation Security Administration, December 2, 2016, https://www.tsa.gov/for-industry/intermodal-security-training-and-exercise-program.

[171] The transportation modes include aviation, pipeline, freight rail, port and intermodal, highway and motor carrier, and mass transit, and passenger rail.

According to the TSA, "the program assists transportation partners to build and sustain security preparedness to protect travelers, enhance national resilience, and identify capability gaps and needed resources."[172] The benefits of the program include enhanced security capacities in incident management, partnership building with transportation security owners and operators, emergency responders, and local law enforcement, and implementation of best practices and risk-based approaches from lessons learned. The I-STEP program also provides the Exercise Management Services and the Exercise Information System (EXIS) to equip industry with the appropriate tools to conduct and assess risk-based security preparedness and resilience.[173] Although protecting soft targets is not specifically mentioned, the key feature of EXIS is to provide comprehensive scenarios tailored to each transportation mode, free of cost. This feature may cause industry leaders to assess and build plans not only to protect their business, but the infrastructure and people that use it.

2. Barriers to Implementing STS Policies

Thus, what are the barriers to soft target crowd protection? As described earlier, unlike the United Kingdom's airport strategy, there are no universal policies for police and local law enforcement at U.S. airports. Instituting a common practice for soft target protection in the United States faces several barriers. First, U.S. laws (federal and state) mandate that local police or the FBI (not the TSA) regulate terrorist and criminal elements. Therefore, in the airport environment, the police must conduct the monitoring and protection of crowded spaces. Second, law enforcement policy implementation across U.S. national airports varies; thus, a discrepancy occurs from institutions, industry, and the culture of these organizations. Third, since a large number of people in the United States do not support the increase of the TSA (nor the government), European homeland security practices are not easily transferrable to the United States.

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[172] Transportation Security Administration, "Intermodal Security Training," paragraph 3.

[173] "Exercise Information System," Transportation Security Administration, December 5, 2016, https://www.tsa.gov/for-industry/exercise-information-system.

Finally, private institutions, airports, and airlines in the United States want to maintain the control of security practices, and overreach by the government is not viewed as a welcoming practice. This view is opposite that of the UK and EU culture, where the majority of citizens fully support their government's involvement and cooperation. The United Kingdom's widespread CCTV system is a great example. Additionally, in the Czech Republic, the government of the Ministry of Interior partnered with the Soft Targets Protection Institute to establish thorough guidelines for STS.[174] Their document, the *Basics of Soft Targets Protection Guidelines*, demonstrates best practices and policies that govern STS and are an excellent example for others to follow. Again, this document shows how European countries have partnered with their governments to address soft target protection head on.

According to the United Kingdom's DfT's *Airport Security Planning Quick Guide*, "a Risk Advisory Group (RAG) brings together security practitioners at the airport, including representatives of the airport manager and local chief of police."[175] Although airports in the United States also have similar working groups to review their ASPs, this system is not standardized like the United Kingdom's RAG. In the United Kingdom, the RAG develops a risk report that is the impetus of the ASP's development.[176] At U.S. airports, however, the situation is entirely different because each airport's ASP is usually developed locally to adhere to CFRs. The UK's approach to aviation security, in this example, is proactive, uniform, and coherent. This UK practice can actually be transferred to U.S. practices that would enable a standardized and effective approach to aviation security. If groups, such as RAGs or SEG were formed in the United States, they can travel from one airport to another to assess risk, including soft targets, and implement a standardized system not only to have the ASPs adhere to the CFRs, but to also mitigate any threats previously not addressed. Some significant leadership roles from the DHS, TSA, and local stakeholders would be required to

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[174] Zdeněk Kalvach, *Basics of Soft Targets Protection Guidelines* (Prague: Soft Targets Protection Institute, 2016), www.mvcr.cz/cthh/soubor/basics-of-soft-target-protection-guidelines.aspx.

[175] Department for Transport, *Airport Security Planning Quick Guide*, 5.

[176] Department for Transport.

implement such a system, and it is highly plausible and transferable. As discussed earlier, this public-private partnership is critical in assessing and mitigating the risk toward crowded spaces. Establishing policies to strengthen these ties directly would prove to be effective in the United States.

3. EU and U.S. Approach to Homeland Security

The driving force and key in this comparative policy analysis between the European Union and the United States is the overarching approach to homeland security. Frank Gregory attests that for the United Kingdom, "the very proper public debates on the governance capacity to respond to terrorism post 9/11 has often been polarized around arguments for and against the UK variable 'lead department' model versus the US centralized Department of Homeland Security."[177] He makes the argument that such a "centralized" department is not required for the United Kingdom. He highlights the criticisms that the DHS, like the United Kingdom's Home Office, meets the same communication, inter-agency cooperation, and synchronization issues as their own government, and that having a lead agency would not resolve this issue. He further attests that Hazel Blears (former Home Office Counter-Terrorism Minister) agrees that the UK government "already has a crosscutting resilience programme to continue improving the coordination of civil counter-terrorism research," and that she believes "this adds more value that a stand alone centre for home defense."[178]

Although United Kingdom's Home Office is comparable to the United States' DHS, its approach to homeland security is unique. Since the Home Office takes the *lead role* in policy development, such as CONTEST, the protection of soft targets, crowds, and community resiliency are administered collectively within each sub-institution; unlike in the DHS whose sub-agencies have separate missions within the umbrella of the DHS. Furthermore, according to Frank Gregory, a "tradition of inter-department

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[177] Frank Gregory, "Chapter 6: National Governance Structures to Manage the Response to Terrorist Threats and Attacks; A Cross-national Comparative Analysis with Special Reference to the UK 'Lead Department' Response Structure and UK Counter-terrorism Strategy," in *Homeland Security in the UK, Future Preparedness for Terrorist Attack Since 9/11*, ed. Paul Wilkinson (New York: Routledge, 2007), 118.

[178] Gregory, 120–121.

coordination via the Cabinet Office" exists in the United Kingdom.[179] In essence, this approach has a greater impact because the mission objectives are in a higher echelon of government. Additionally, the DfT, "is the security regulator and as such provides support in relation to counter-measures for the full range of terrorist and other threats to the transport industries."[180] Again, the TSA is limited in its range of terrorism counter-measures and primarily relies on other Executive Branch departments to assist in this endeavor.

Since the approaches to homeland security differ between the United States, European Union and United Kingdom (a centralized versus a lead department role), the European counter-terrorism strategies are not easily transferable to the U.S. system. First, the DHS would have to adopt the strategy, such as CONTEST, at the helm of the DHS and integrate it within each sub-agency. The sheer size of this undertaking would cause departmental challenges. Second, as Frank Gregory points out, the DHS is "not a static comparator model but rather an evolving structure" and this type of structure may help absorb some of the changes, or deflect them. Third, U.S. citizens would have to provide public and private support. Even though the EU and UK policies for STS rely heavily on the public-private relationship, U.S. stakeholders would need a buy-in that may not be guaranteed. Finally, because the United States has states and governors, implementing similar EU/UK strategies would depend on these local and state structures.

The UK Home Office is in a better position to enact policy change than the DHS because of its position in government and its role in homeland security, which is mainly to lead and create policy. In contrast, the DHS serves mainly in an executive and operational role, which makes the UK system more flexible and adaptable to change in accordance to the threat. Additionally, as the Home Office can lead policy, it has direct authority in coordinating efforts for count-terrorism throughout the county; whereas the large size and operational element of the DHS is more challenging. This policy analysis finds that the DHS can learn from the Home Office model by being more engaged in leading policy change and emulating a similar strategy, such as CONTEST. Another

[179] Gregory, 119.

[180] Gregory, 119.

option is to form a counter-terrorism standing committee of federal and local police, airport, airline, and other key aviation subject matter experts to address the protection of crowds, specifically.

4. Policy Relevance

Why is the discussion of the policies comparison important? The policies for soft target protection provide the framework in how federal, state, and airports tackle the protection of crowded spaces and aviation transportation. The policy analysis shows that that EU member states (Belgium and the United Kingdom) have made soft target protection and infrastructure resiliency a *core policy priority* for protecting the transportation modes and the aviation industry. They adhere to a *systematic and deliberate method* to protect crowded spaces. Private industry and business maintain their security plans and design their buildings based on such policies. When UK and Belgium industry leaders think about protecting crowded spaces, people, and critical infrastructure, they plan, build, and exercise with this concept in mind. Ultimately, the people and the nation's critical infrastructure are at the core of national security; without them a country may not survive. The United States has been fortunate with limited attacks to soft targets, in comparison to Europe, but that does not mean the nation should not be prepared and committed to a proactive approach, which is ever more crucial in critical infrastructure and global aviation.

III. CASE STUDIES

The attacks at Brussels, Los Angeles, and Glasgow provide an opportunity to surmise how environmental design can affect target selection, as well as an outcome of an attack. When an incident occurs at an airport, the tendency is to increase the security posture. An immediate reaction by authorities is to deploy heavily armed police, security, and military forces after the event takes place.[181] This reaction reassures the traveling public that threats are taken seriously and the authorities are prepared to handle the situation. How long, however, is this type of enforcement presence maintained? In most instances, this deployment is a reactionary response that is by no means permanent. The amount of human capital needed to sustain such a security front is costly and implausible. Furthermore, it is highly unlikely that another attack would occur in the area that has seen an influx of security forces.

Grant and Stewart cite a START research study that finds that 72 percent of airport attacks have been the result of a bombing or attempted bombing.[182] They posit that, "these attacks demonstrate that airport terminal operators need to consider the threats associated with IED attacks as part of their design activities, carefully negotiating a design to a position where the threats posed by an IED attack are measured against the economic viability of the infrastructure being designed."[183] They surmise that protecting an airport is not much different than providing security in a mall, with the exception of choke-points intended to block adversaries from attacking aircraft. They proclaim, "consideration of the structure and format of existing security layers, and the potential for an IED attack directly upon a security point, check-in counter or baggage reclaim point, is an equally valid endeavor, and may provide significant threat reduction to personnel

[181] This type of reaction occurred in the Brussels and Turkey attacks.

[182] National Consortium for the Study of Terrorism and Responses to Terrorism, *Fact Sheet—Armed Assault at Los Angeles International Airport (LAX)* (College Park, MD: University of Maryland, 2013), start.umd.edu/pubs/STARTFactSheet_ArmedAssaultatLAX_Nov2013.pdf.

[183] Matthew Grant and Mark G. Stewart, "Benefit of Distributed Security Queuing for Reducing Risks Associated with Improvised Explosive Device Attacks in Airport Terminals," *ASME J. Risk Uncertainty Part B* 3, no. 2 (2017): 021003-1, doi: 10.1115/1.4035730.

for little additional expenditure."[184] Morral et al. and Jackson et al. also recognize that airport ground-based attacks are increasing and that they are simpler to carry out by an adversary.[185] Thus, how can a more manageable and permanent solution be implemented? The following case studies provide an analysis of how environmental design can influence target perception.

A. BRUSSELS

The terrorist attacks in Brussels on March 22, 2016 demonstrated the vulnerability of soft targets. The events that unraveled at Brussels International Airport (Zaventem) caused government entities and aviation industry leaders to re-think airport security measures for crowd and infrastructure protection. The proceeding case study examines the airport's strategic geophysical position and economic significance. A descriptive analysis of the terrorists' background, objectives, and attack is provided. An illustration of the airport's configuration and infrastructure are examined to provide a comprehensive case analysis. The case study concludes with implications for airport design for STS.

1. Airport Description and Relevance

Brussels International Airport, also known as Brussels-National or Zaventem, was built in 1994 and is located approximately eight miles northeast of the capital of Belgium.[186] The Belgian Air Force base is co-located on the airport grounds and it shares the runways with commercial traffic. The airport's location makes it an important commercial and military critical infrastructure asset. The European Union, EC, and NATO headquarters also reside in the capital, and their location make the airport a strategic position for European security.

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[184] Grant and Stewart, "Benefit of Distributed Security," 021003–021002.

[185] Andrew R. Morral et al., *Modeling Terrorism Risk to the Air Transportation System—An Independent Assessment of TSA's Risk Management Analysis Tool and Associated Methods* (Santa Monica, CA: RAND, 2012), https://www.rand.org/content/dam/rand/pubs/monographs/2012/RAND_MG1241.pdf; Brian A. Jackson et al., *Efficient Aviation Security: Strengthening the Analytic Foundation for Making Air Transportation Security Decisions* (Santa Monica, CA: RAND, 2012); Grant and Steward, "Benefit of Distributed Security," 021003–021002.

[186] Wikipedia, s.v. "Brussels airport," November 17, 2017, https://en.wikipedia.org/wiki/Brussels_Airport; "About Brussels Airport," Brussels Airport, April 4, 2017, https://www.brusselsairport.be/en/corporate/bru.

The airport is a crucial economic asset for the Belgian economy. In 2016, the airport served about 22 million passengers (~60,000 per day), making it one of the busiest airports in Europe and comparable to any Category X airport in the United States. It provides connections to 238 destinations by 78 airlines.[187] Brussels airport is a hub for Brussels Airlines, TUl fly Belgium, and Singapore Airlines Cargo. As such, Brussels is an important node in the global passenger and commercial aerospace economy.

The airport is an important critical infrastructure asset because it is Belgium's largest employer in the area. It supports approximately 20,000 workers, another 60,000 in the local community, 260 businesses, and contributes a 1.8% share in the national GDP.[188] The airport services both passenger and cargo general aviation, and thereby ensures business and commerce flourish. Furthermore, from 2000 to 2015, the number of passengers per flight increased by 60%.[189] This growth indicates that the airport is an integral part of Belgium's economy. The Brussels Airport Company is the owner and operator of the airport, in which the Belgian state owns 25% of the shares.[190] For this reason, this airport is an essential economic component for the country as well. These factors demonstrate the airport continues to be an attractive target for terrorists because of the impact to the economy, society, and region.

2. Synopsis of Attack Event

On March 22, 2016, terrorists coordinated bombings at Brussels International (Zaventem) airport and the Maalbeek metro station that killed 32 people and injured over 300 others.[191] The event was claimed and supported by Islamic State in Syria (ISIS). The

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[187] Brussels Airport, "About Brussels Airport"; "We Love Passengers," Brussels Airport, accessed November 17, 2017, https://brusselsairportinnumbers.brusselsairport.be/en#we-love-passengers.

[188] Matthieu Demeestere, "Brussels Airport Eyes Sunday Reopening as Govt, Police Agree Security Deal," *Digital Journal*, April 1, 2016, http://www.digitaljournal.com/news/world/brussels-airport-reopening-nears-as-security-deal-reached-with-police/article/461768; Wikipedia, "Brussels airport."

[189] "Modernizing Brussels Airport," Brussels Airport, 2017, https://www.brusselsairport.be/en/corporate/history/zaventem2.

[190] Brussels Airport; Wikipedia, "Brussels airport."

[191] Mario Arturo Ruiz Estrada and Evangelos Koutronas, "Terrorist Attack Assessment: Paris November 2015 and Brussels 2016," *Journal of Policy Modeling* 38, no. 3 (April 2016): 2, http://dx.doi.org/10.1016/j.jpolmod.2016.04.001.

airport CCTV captured the faces of three suicide bombers, and two additional suspects were later identified and arrested.[192] The terrorists belonged to the same cell as the 2015 Paris attackers, and they struck Brussels shortly after the Belgian police raided their network in the Belgian suburbs on March 15 and 18, 2016.[193]

The terrorists attacked the airport in two landside terminal check-in locations (check-in row 11 and 2) using homemade IEDs hidden in large luggage (see Figure 8).[194] Security footage showed them maneuvering the baggage through the terminal with luggage carts.[195] The detonation occurred roughly 10 seconds apart near the Starbucks shop and Delta Airlines ticket counter. The IEDs were comprised of triacetone triperoxide (TATP) (a highly volatile explosive that can be made by mixing common chemicals sold in stores) and were also combined with nails and screws to maximize damage.[196] According to a BBC article, "witnesses said people ran from the site of the first blast, only to be caught in the second, near the main entrance."[197] This approach indicates that the attack was strategically planned to maximize the number of civilian casualties. Firefighters discovered a third larger suitcase bomb during a search for survivors. It was detonated through a controlled explosion inside the terminal and caused

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[192] "Brussels Attacks: Updates," Politco, March 30, 2016, http://www.politico.eu/article/brussels-attacks-live-blog-isil-terror-2016-malbeek-zaventem/.

[193] Larry Buchanan and Haeyoun Park, "Uncovering the Links between the Brussels and Paris Attackers," *New York Times*, April 9, 2016, https://www.nytimes.com/interactive/2016/03/23/world/europe/how-the-brussels-and-paris-attackers-could-be-connected.html; Greg Botelho and Steve Almasy, "Raid of Belgian Building Tied to Paris Terror Attacks Ends with 1 Dead," CNN, March 15, 2016, http://www.cnn.com/2016/03/15/europe/brussels-paris-attacks-shots-fired/index.html; "Brussels Raid: Paris Suspect Addeslam's Fingerprints Found in Flat," BBC News, March 18, 2016; Jason Burke, "Why Did the Bombers Target Belgium?" *Guardian*, March 22, 2016, https://www.theguardian.com/world/2016/mar/22/why-was-belgium-targeted-by-bombers.

[194] "Brussels Explosions: What We Know about Airport and Metro Attacks," BBC News, April 9, 2016, http://www.bbc.com/news/world-europe-35869985; Wikipedia, s.v. "2016 Brussels bombing," last updated December 9, 2017, https://en.wikipedia.org/wiki/2016_Brussels_bombings.

[195] Charlotte Alfred, "What the Bombs Used in Brussels Reveal about the Attacks," *Huffington Post*, March 23, 2016, https://www.huffingtonpost.com/entry/bombs-brussels-attacks_us_56f2a25fe4b0c3ef52174c1d.

[196] BBC News, "Brussels Explosions"; "What Happened at Each Location in the Brussels Attacks," *New York Times*, March 22, 2016, https://www.nytimes.com/interactive/2016/03/22/world/europe/brussels-attacks-graphic.html.

[197] BBC News.

significant structural damage.[198] This bomb was left by the third suicide bomber who escaped the scene and was later detained by the police. The third bomb was larger in size and would have caused extensive life loss if it had detonated.

Figure 8. Brussels Zaventem Airport Attack Sequence.[199]

The explosions occurred in the public side departure hall, where approximately 26 airlines have ticket counters.[200] A picture taken minutes before the explosion by Kardava reveals that the attackers had strategically positioned themselves in the midst of the crowd.[201] The timing of the event (08:00 AM) also indicates that the terrorists chose a busy time in the airport check-in terminal as multiple flights were preparing to board. The shockwaves from the explosions caused debris, dust, shattered glass windows, roof tiles,

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[198] David Gordner, personal communication, December 29, 2017; See Also "Photos Show Damage inside Brussels Airport after Attack," NBC News, March 30, 2017, https://www.nbcnews.com/storyline/brussels-attacks/photos-show-damage-inside-brussels-airport-after-attack-n548071; "Terror in the Terminal," *Daily Mail*, March 23, 2017, http://www.dailymail.co.uk/news/article-3503928/Two-explosions-heard-Brussels-Airport.html.

[199] Source: Demeestere, "Brussels Airport Eyes."

[200] "Map of Departures Hall," Brussels Airport, accessed September 21, 2017, https://www.brusselsairport.be/en/passngr/at-the-airport/deplevel.

[201] "Gemma Mullin, "Brussels Attacks: First CCTV from Inside Packed Airport Terminal Shows Travellers Seconds before Twin Explosions," *Irish Mirror*, March 25, 2016, http://www.irishmirror.ie/news/world-news/brussels-attacks-first-cctv-inside-7621061.

and surrounding elements, which further injured the passengers.[202] Video footage from the attack shows individuals attempting to navigate through the passenger queue stanchions, seek cover, or escape through dispersing smoke.[203] Aftermath images show infrastructure destruction of interior ceiling panels; air-conditioning and ventilation systems, shattered glass, displaced stair railings, metal fixture debris from support columns, ticket counter metal and plastic detachments, electrical wiring exposure; scattered sheetrock and wood supports, fallen brick, and exposed pipes (See Figure 9).[204] Additionally, fire erupted after the blast that burned several individuals and caused further infrastructure damage.

Figure 9. Attack Aftermath Interior and Exterior of Departure Hall.[205]

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[202] Simon Tomlinson et al., "Terror in the Terminal: Chilling Footage Shows Moment Passengers Cower under Desks and Run for Their Lives in Immediate aftermath of Twin Blasts," *Daily Mail*, March 22, 2016, www.dailymail.co.uk/news/article.../Two-explosions-heard-Brussels-Airport.html.

[203] Daily Mail, "Terror in the Terminal."

[204] Daily Mail; See also NBC News, "Photos Show Damage inside Brussels Airport after Attack"; kaustubh, "KK Travails," *Myblogkaustubh* (blog), March 22, 2016, https://myblogkaustubh.wordpress.com/2016/04/22/kk-travails/.

[205] Adapted from (Picture 1), "Brussels Explosions: Devastation and Chaos after Attacks," BBC News, March 22, 2016, http://www.bbc.com/news/world-europe-35870273. (Per news article, this picture was taken by Martine Roegies who preferred not to speak about the event); Adapted from (Picture 2), "Brussels Airport Bombers Targeted US, Jews: Probe," *Deccan Chronicle*, January 24, 2017, http://www.deccanchronicle.com/world/europe/240117/brussels-airport-bombers-targeted-us-jews-probe.html. (Photo by AFP).

3. Attack Impact on Security

The impact and damages of the attack resulted in an airport shutdown for 12 days; full operations were resumed three months later.[206] It operated at 20% passenger capacity (~800 pph) when it reopened on April 4, 2016.[207] This number indicates that terminal capacity at full load would be approximately 4,000 pph. The passenger capacity number indicates that crowds form during peak operation hours. Not only does this mean that crowds will form daily, but the times and locations can be quickly predicted and are readily accessible by terrorists in the public sphere, which makes it an attractive target for adversaries.

The attacks cost the Belgian economy an estimated four billion euros.[208] Within three months, on June 28, the Turkish Istanbul Ataturk airport terminal was similarly attacked by terrorists using both firearms and IEDs that killed 36 people.[209] Although not terrorist inspired, in June, another homemade bomb attack was carried out in Shanghai Pudong airport that injured four people.[210] An airport attack trend began to develop in a short period of time.

Belgian authorities immediately reacted to the Brussels attack by sending security forces, police, and military to cordon the airport. Following the attacks, government and industry leaders continue to seek appropriate methods to secure public terminal spaces appropriately. What are required; more canines, more police presence, higher show of force, or additional security measures? Industry leaders examined the possibility of including additional checkpoints, possibly before the terminal entrance. In fact, a security tent was indeed set up on entry to the Brussels airport terminal that resulted in large

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[206] Grant and Steward, "Benefit of Distributed Security," 021003–021002.

[207] "Brussels Airport Expected to Partially Re-open after Deadly Attack," CBC News, March 31, 2016, http://www.cbc.ca/news/world/brussels-airport-reopen-belgium-attack-1.3515400; Wikipedia, s.v. "Brussels airport."

[208] Damien Sharkov, "Brussels Attacks to Cost Belgium $4.47 Billion," *Newsweek*, March 23, 2016, http://www.newsweek.com/brussels-attacks-cost-belgium-4-billion-euros-440013.

[209] Eugene E. Guang Tan, *Checkpoint or Chokepoint: Aviation Security Lessons from Istanbul and Brussels*, RSIS Commentaries, No. 184 (Singapore: Nanyang Technological University, 2016), 1, http://hdl.handle.net/10220/41019.

[210] Tan, 1.

crowds at peak travel times.[211] However, ACI Europe proclaimed that adding or moving screening checkpoints is not a viable option because it creates new security vulnerabilities by presenting new targets.[212] In other words, the target had simply moved. Furthermore, following the Brussels attack, the EC halted new EU legislation on imposing checkpoints in airport entrances.[213]

According to the Brussels Airport, the departures terminal hall remains closed to passenger drop-off by vehicle. New drop off zones were created in the vehicle parking areas (P1, P2, and P3) are designated as the "drop-off" zone. The new zone is a considerable walk (~5 minutes) for people and families that may be carrying luggage to the terminal.[214] Additionally, Brussels Airport is notifying all passengers that they may be randomly searched via walk-through metal detector and baggage search before entering the terminal building. The same applies for those who want to access the arrivals level and baggage claim area where they are meeting incoming passengers. Belgian Federal Police with behavior awareness training are stationed at airport entrances and may pull aside suspicions individuals for additional screening before they are allowed to proceed to the terminal.[215] Those entering through the bus stop and train rail levels are also subject to screening before entering the terminal.

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[211] "Letter 27 April 2016"; Alan Hope, "Brussels Airport Temporary Check-ins Working Smoothly," *The Bulletin*, April 5, 2016, http://www.xpats.com/brussels-airport-temporary-check-ins-working-smoothly.

[212] Aviation Security Committee, *Airport Landside Security*.

[213] Oliver Jankovec, "ACI Europe Letter 28 April 2016 to Prime Minister Dmitry Medvedev Landside Security Measures," ACI Europe, April 27, 2016, https://www.aci-europe.org/policy/position-papers.html?view=group&group=1&id=4.

[214] "Additional Security Measures Apply to Ensure Your Safety," Brussels Airport, accessed October 15, 2017, https://www.brusselsairport.be/en/passngr/deppax/secmeasures; "Dropping Off & Picking Up Passengers," Brussels Airport, accessed October 15, 2017, https://www.brusselsairport.be/en/passngr/to-from-brussels-airport/pickupdropoff; "Dropping Someone Off by Car," Brussels Airport, accessed October 15, 2017, https://www.brusselsairport.be/en/passngr/to-from-brussels-airport/pickupdropoff/paxdropoff; "Tips for a Smooth Departure," Brussels Airport, accessed November 17, https://www.brusselsairport.be/en/passngr/deppax/tipstricks.

[215] David Gordner, email message to TSA Representative to the European Union, the Kingdom of Belgium, Luxembourg, and Switzerland, December 29, 2017.

4. Airport Configuration and Design

The infrastructure, layout, and materials design of the airport play a significant role on the impact resulting from an interior explosion. According to Binder, Moffett, and Montois, phase 1 of the airport terminal was constructed by the Brussels Airport Terminal Company and completed in 1994.[216] The terminal was built to 220 meters by 120 meters and "spreads over eight levels, of which three are largely open to the public."[217] Glass walls surrounded the building exterior, where the hall ends in a diamond shape that connects to the lower levels. The roofs of the main terminal and diamond atrium were also encased in glass.

According to the Brussels' Airport website, the terminal departures hall has 10 check-in ticket counters with 25 airline desks, where some airlines share the counters (see Appendix C).[218] They face each other in a parallel form and each counter has a passenger queuing area and automated kiosk check-in (see numbered counters in Figure 12). As a result, the check-in area is a concentrated soft-targets node. Such nodes concentrate traffic and prove to be attractive targets for attackers. At the same time, defenders can concentrate resources in that area to protect that node.

The hallway to access food and shops is perpendicular to the airline counters; and people migrate between the terminal check-in and security to enter into the main departing piers (see right picture in Figure 10 and purple shaded areas in Figure 12). This layout increases crowd density in this area because people are both transitioning from one location to another to access gates, and stopping for food, drinks, and shopping. Figure 10 shows a side-by-side comparison from Binder after post construction, and from a recent article by Magnusson of the terminal before the attacks of 2016. The location of the

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[216] Georges Binder, Cleveland Moffett, and Henri Montois, *Montois Partners: Selected and Current Works*, The Master Architect Series, vol. IV. (Mulgrave, Victoria: Images Publishing Group, 2001).

[217] Binder, Moffett, and Montois, 54.

[218] Brussels Airport, "Map of Departures Hall"; Airline desks include Emirates, Air Algerie, Egyptair, Ethiopian Airlines, Brussels Airlines, Austrian, Swiss, Croatia Airlines, Swissport, Lufthansa, Al Italia, United Airlines, Turkish Airlines, TAP Portugal, Air Serbia, Delta Air Lines, TAROM, Aeroflot, Blue Air, El AL, Aviapartner, British Airways, Iberia & Aer Lingus, Hainan Airlines, Royal Air Maroc, Corendon, Thomas Cook, Neckermann & Pegase, TUl Fly, Sunjets, and VIP.

airline ticket counters is to the left of the crowd (main hall), which is not visible in this picture. In essence, additional crowds form in that location.

Figure 10. Departure Hall Transit Hallway.[219]

Passengers move from the main departures hall to access the concourses of Pier A and B through a security screening checkpoint via the *Connecter* building that links passengers between the two (see Appendix C). The airport uses a total of 109 gates.[220] Pier A serves Schengen flights (gates A1–A60) and non-Schengen flights (gates T61–T72).[221] An estimated 60% of passengers connect to the Schengen area.[222] This percentage indicates a mixture of EU member states non-visa holders with foreign

[219] Source (Picture 1, left): Binder, Moffett, and Montois, *Montois Partners*, 55; See also "Brussels Airport, Zaventem," Bontinck Architecture and Engineering, accessed November 20, 2017, http://www.bontinck.biz/en/projects/non-residential/1971-brussels-airport; Source (Picture 2, right): Ari Magnusson, "Brussels Airport Departure Terminal Reopens: Is Heightened Security the New Normal?" Apex, May 3, 2016, https://apex.aero/2016/05/03/brussels-airport-departure-terminal-reopens-is-heightened-security-new-normal. (Picture 1: Reprinted with permission).

[220] "Brussels Airport Terminal," Brussels Airport, accessed November 17, 2017, https://www.airport-brussels.com/terminal.php.

[221] Brussels Airport; "Brussels Airport Tour," Expat Club, 2017, https://expatclub.org/event/couden berg-2/.

[222] Expat Club; "Migration and Home Affairs, Schengen Area," European Commission, last updated December 20, 2017, https://ec.europa.eu/home-affairs/what-we-do/policies/borders-and-visas/schengen_en. The Schengen Area allows individuals to cross international borderers without passport visas within the EU member states or countries incorporated into the Schengen Area.

country visa holders, where additional passport checks must be conducted. Pier B connects to the main departure hall and encompasses non-Schengen flights on two levels (Level 3, gates B1–B40; and Level 0, gates B80–B98). Level 4 of the airport includes shops, restaurants, bars, and other customer lounge services.[223]

The Brussels Airport has one main departures and arrivals terminal with multiple levels that connect several modes of transportation in one building (rail, motor vehicle, and aviation). The levels include: Level 1 (railway station), Level 0 (buses and taxis); Level 2 (arrivals), and Level 3 (departures) (see Figure 11).[224] Passengers move about the levels through escalators and elevators. The multiple modes of transportation provide complexity to the airport infrastructure because an impact to one mode may significantly disrupt the others. The rail and bus transportation feeds into the city, where many commuters rely on public transportation to move about.

Figure 11. Brussels Airport Multiple Levels/Multiple Modes of Transportation.[225]

The configuration of the airport is an essential factor for risk-assessments and attack mitigation. For example, the Brussels attack *de facto* impacted the other modes of

[223] Brussels Airport, "Brussels Airport Terminal."

[224] Brussels Airport.

[225] "Check-in at Desk," Bruxx, accessed November 20, 2017, https://www.bruxx.be/en/airport-info/check-in/at-the-desk.

transportation, which further escalated the economic loss to the surrounding community and businesses supporting the airport and Brussels city. Airport infrastructure damage may have increased and become more severe if the attack also encompassed the multiple layers of this structure. When several modes of transportation come together in one location, the level of risk increases. Using terminology from Network Theory, multiple nodes, serving multiple networked systems are co-located. Such concentrated systems are prime targets for attack.

5. Case Analysis: Brussels

The damage arising from the IED blast impact was amplified by the configuration and construction of the interior passenger terminal. To estimate the impact of this attack, data from the Brussels Airport passenger throughput statistics from the February report (Table 1) was analyzed. These data provide normalized passenger trends near the month of attack. The number of total departing passengers equates to a conservative number of 27,337 per day, which is an estimated average of 1,608 pph in the terminal departure hall.[226] A fraction of passengers (i.e., originating, transfer, and transit) will exit the sterile side to the departure hall to access the outside, while others will transition to the Connector; because these numbers cannot be parsed from the available data; keeping the conservative number decreases the margin of error. During the attack in Brussels, 32 people were killed; which puts the attack death ratio to 2%. Approximately 300 people were injured, and this number equates to 19% of human injury per passenger capacity.[227] Although this number provides a rough estimate of threat impact, it puts soft target security in perspective.

Risk assessments need to consider human loss and incorporate mitigation plans. The airport has operated for 24 years, with one significant attack during this duration. The risk over the lifetime of the airport, hence, provides a 0.002% probability of human

[226] The pph was calculated as (27,337/17 hrs.) because normal airline counters are open from 04:00 AM to 09:00 PM. In this case, the curve is equally distributed, when in reality, the influx would have higher passenger numbers during peak intervals. The average estimate is intended for comparison analysis only.

[227] Equations are [100(32/1608)] and [100(300/1608)].

injury, which is about 20 times the risk of dying in an airplane crash.[228] The question then arises, is this ratio an acceptable human injury rate in a public space of a terminal?

Table 1. Passenger Throughput for February 2016.[229]

	February		
	2016	2015	growth
Total number of passengers	1,570,590	1,411,776	11.2%
Total Departing Passengers	792,791	719,419	10.2%
Originating	626,983	579,938	8.1%
Transfer	148,962	122,844	21.3%
Transit	16,846	16,637	1.3%
Arriving pax (excl Transit)	777,799	692,357	12.3%

Brussels Airport, Corporate Statistics

The events in Brussels revealed that blast resiliency in physical structures must be assessed. Even if blast-proof material cannot be designed into the configuration, it is critical to consider how blast shockwaves create deadly debris. The scope of this study examined crowd formation and movement in airport design. For example, it is known that crowds will form in front of ticket counters at least two hours before a flight. This type of predictability in crowd behavior is inherent in the design. Square footage occupied by people increases when the ticket counters are juxtaposed. Adding shops and restaurants in the public space additionally increases the number of people. Individuals will linger longer in these areas and possibly even extending their good-byes with loved ones. When adversaries seek to cause harm, these easily accessible places become targets to attack masses.

The terminal layout and configuration play a significant role in the success or aversion of an attack on soft targets. Using the game theory attacker-defender model, terrorists choose an attack on soft targets because of the crowd predictability. If an

[228] Airport operations = 24 years (from 1994–present). Equations are [24(365)=8,760 days] with a probability of [20/8,760=0.002%].

[229] Source: "Monthly Traffic Figures," Brussels Airport, accessed November 21, 2017, https://www.brusselsairport.be/en/corporate/statistics/monthly-traffic-figures.

adversary can perceive success of the attack because the crowd cannot disperse, the attack damage is high, or that the risk of executing such an attack is low, then the probability of target selection is high. All these elements relate to the attackers' *perception* of their operations' success within the environment in which they carry it out. The 12-day airport shutdown, with minimized capacity when re-opened, attests to this fact.

Figure 12 depicts the general layout of the Brussels main departures hall. The areas accessible to the general public are highlighted in light red. The red X's indicate areas of predictable crowd formation at the check-in counters but does not mean these areas are the *only* ones to which the crowds navigate. As shown in Figure 12, the crowds also migrate to the main hall next to the shops (shown in purple shading). For example, the yellow arrows in the figure indicate possible crowd movements where people must circle around the ticket counters to navigate between them. Looking at this diagram, possible pinch-points can be surmised where people inhabit more space per square footage. Protection countermeasures for STS should focus on these areas. The terrorists' choice of location in the second explosion in Figure 8 demonstrates bottlenecks in crowd movement. These locations form densely populated areas as passengers move past the shops from the check-in counters, subway, and buses from the lower floors and to the passenger-screening checkpoint. Picture 2 on Figure 10 and CCTV footage of the event supports this assertion.[230]

[230] New York Times, "What Happened at Each Location in the Brussels Attacks." This article provides a timeline of events, diagrams, and pictures of the attack. The diagram depicting the departure hall shows the pinch point bottlenecks where passengers move from the ticket counters, past the escalators from the lower floors toward the screening checkpoint. Mullin, "Brussels Attacks."

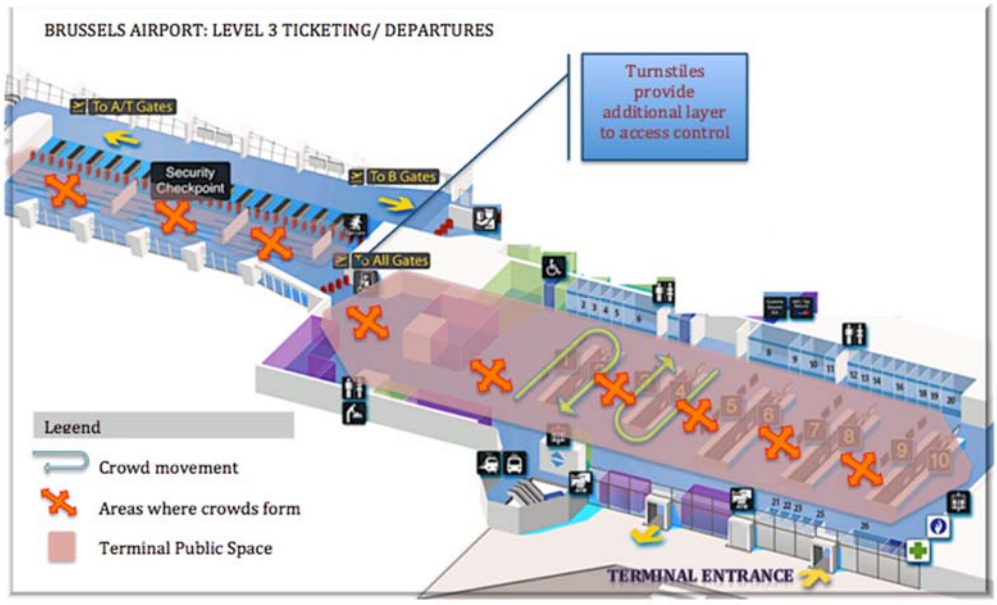

Figure 12. Terminal Scenario Analysis.[231]

Access control turnstiles stationed before passenger security screening in the Connector building represent a positive environmental design (depicted as dark red marks in Figure 12). Similar turnstiles are also fitted in the lower level of the rail station.[232] This location not only controls access to those who do not have a boarding pass, but it also adds extra layers to security. For example, the terrorists would not have been able to access this area without a boarding pass. Passengers normally carry small *carry-on* luggage through the screening checkpoint and the terrorists would not have been able to push the large luggage carts through the turnstiles (see Figure 13). Additionally, luggage carts do not fit through these turnstiles. Hence, even if they had a boarding pass, the terrorists would have been out of place and possibly alarm those around them if they attempted to enter through this area with luggage carts. This design element is a perfect example of the *surveillance* CPTED principle because the built-in environmental design provides deterrent countermeasures and increases human risk perception that hence attributes to minimizing potential attacks.

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[231] Adapted from "Route Pier A (A/T Gates)," Bruxx, accessed November 20, 2017, https://www.bruxx.be/en/airport-info/maps.

[232] "Gates at Brussels Airport- Zaventem Station," Belgian Rail, accessed November 20, 2017, http://www.belgianrail.be/en/stations-and-train/airport-connections/gates.aspx.

Figure 13. Turnstiles Placed before Passenger Checkpoint Screening.[233]

According to the Brussels airport, the Connector building opened on March 24, 2015 to assist passengers in crossing between Pier A and Pier B and to deliver improved security screening.[234] This relatively new building houses a modern security screening checkpoint and border control for visa verification. The architects of the building, Chapman Taylor, designed the glass façade to withstand 160 kilometers of wind speed per hour from aircraft jet engines.[235] If the exterior glass walls of the older main terminal were also comprised of these minimum features, then perhaps the shattered glass would not have caused as much damage (refer to Figure 9 of the departure hall). Encasing an entire structure with glass is risky when considering blast protection. Particularly, architects and engineers need to deliberate the amount of explosives that may cause materials dislodgement and shrapnel in crowded locations due to the building's design. Since the exterior façade of the Brussels airport terminal and parking garage were made with a majority of glass material, an assessment of the infrastructure resiliency needs to be conducted and materials mitigated from explosive shock wave.

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[233] Source: "Brussels Airport Connector," Chapman Taylor, accessed November 21, 2017, http://www.chapmantaylor.com/projects/brussels-airport-connector.

[234] "Connector, Introduction," Brussels Airport, accessed November 21, 2017, https://www.brusselsairport.be/en/corporate/connector/connhome.

[235] "Connector, Architecture," Brussels Airport, February 5, 2015, https://www.brusselsairport.be/en/corporate/connector/connstories/55342, paragraph 9; Chapman Taylor, "Brussels Airport Connector."

The objective is to minimize human harm. The Brussels airport public terminal design induces crowds because passenger queues are closely aligned to each other at the airline check-in counters. Public shops create additional areas for crowds to form. These areas create the pinch-points as previously discussed that thereby increase attack capacity. Moving shops to the secure area decreases crowd capacity and minimizes risk for attack potential and human harm. The Brussels airport strategic vision of 2040 intends to build the terminal of the future with innovative designs that require safety and security standards, and hopefully will take these issues into consideration.[236] For example, after the attack, the renovated glass façade and ceiling materials were made blast resistant.[237] This change is a positive step forward for STS.

6. Implications of Airport Design

The Brussels terrorist attack provides some perilous lessons. The mainstays of risk-based security must be re-evaluated to uncover the core of the threat. Aradau's research reveals that "there has been a move away from the archival-statistical knowledge involved in risk prevention to an enactment knowledge that is produced by 'acting out' future threats," which create new knowledge and transform the calculus of risk and probability.[238] She argues, "the emergence of 'crowded places' as objects of terrorist 'methodology' draws attention to the crowd-subject rather than dispersed populations to be gathered through risk calculations or individual citizens to be disciplined and rendered vigilant."[239] This argument supports the notion that risk-mitigation factors need to be considered from the terrorist's perspective and that relying on calculated risk methodologies alone will not deter the terrorist threat. Attack scenarios must also be considered from the innocent person's point of view, and in the airport environment, from the passengers' point of view. To change policies that govern how this country

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[236] "Connecting Belgium to the Future, Terminal & Airfield, Brussels Airport 2040," Brussels Airport, accessed November 21, 2017, https://www.brusselsairport2040.be/en/vision-2040/63/2d-plans.

[237] David Gordner, email message to author, December 29, 2017.

[238] Claudia Aradau, "'Crowded Places Are Everywhere We Go': Crowds, Emergency, Politics," *Theory Culture & Society* 32, no. 2 (2015): 157, doi: 10.1177/0263276414562429.

[239] Aradau, 158. See also "Protecting Crowded Places from Terrorism," Gov.UK, November 14, 2014, https://www.gov.uk/government/collections/crowded-places.

protects its national security, citizens, and economy, it must first think about people-centric security. Aradau attests to the fact that the UK Home Office supported the competition "Public Spaces, Safer Places" for architects to design security measures for crowded places. The competition received 100 entries, which demonstrates interest and innovation in this type of initiation.[240] Such projects seek to find innovative solutions for the crowd-subject.

Riedman makes a poignant statement when he discusses airport public spaces, "Today the vulnerable point beyond airport security is now an attractive target."[241] His extensive analysis of the terrorist threat toward critical infrastructure reveals that protection policies, such as the National Infrastructure Protection Plan (NIPP), focus on large-scale attacks to *facilities* when in reality they "have rarely been the targets of over 130,000 terrorist attacks across the world over the last 50 years."[242] His analysis of eight U.S. terrorists attacks supports his argument that the current threat from adversaries is to "inflict mass casualties in the locations that are most visible and easily accessible."[243] In other words, soft targets and crowds are the terrorist's main priority, not critical infrastructure *per se*. He asserts that "protection policies should focus instead on determining the most likely targets and the most realistic forms of attack based on goals and capabilities of the terrorist group."[244] Therefore, the terrorist objective of attacking masses must be examined and should not only focus on the impact to critical infrastructure alone.

The Brussels case analysis reveals that terrorists can use homemade bombs to easily inflict mass casualties and significantly impact aviation and transportation security. The attacker's goal must be averted. Environmental design can provide an enduring

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[240] Aradau, 156.

[241] David Riedman, "The Cold War on Terrorism: Reevaluation Critical Infrastructure Facilities as Targets for Terror Attacks," *Homeland Security Affairs* 13, art. 3 (June 2017): 16, https://www.hsaj.org/articles/13976.

[242] Riedman, 19.

[243] Riedman, 19. The eight studies Reidman analyzes include the Orlando Pulse Nightclub Shooting, Boston Marathon Bombing, 9/11 Pentagon, 9/11 WTC, 9/11 Shanksville, Atlanta Olympic Games bombing, Oklahoma City Murrah bombing, and the Dalles Oregon Salmonella attack.

[244] Riedman, 20.

mechanism for this deterrence that other sources of human capital cannot sustain for a long duration of time, such as a military or extensive police presence. They provide physical and dynamic countermeasures as a solution to the threat.

B. LOS ANGELES

Los Angeles International Airport is one of the largest airports in the United States. Its proximity to the city of Los Angeles and its business sustenance makes it a crucial economic asset to the local and national economy. The airport active shooter attack on November 1, 2013, as well as previous attacks, demonstrates the adversaries' choice of soft targets in the homeland. The proceeding case study provides an examination of how the United States is taking measures to counter terrorism threats. The descriptive case analysis provides the shooter's background, intent, and mode of attack. Additionally, emergency response and crowd management are explicated. Finally, the airport's configuration and layout are evaluated to decipher implications for airport design and STS.

1. Airport Description and Relevance

Los Angeles International Airport, known as "LAX," was built in 1929 and is located 16 miles southwest of California's city of Los Angeles (nestled between the cities of Weschester, El Segundo, and Ingelwood).[245] Encompassing about 3,500 acres of land with four parallel runways, LAX is one of the largest airports in the world.[246] It is also the second busiest airport in the United States and one of the most important economic contributors to America's aviation industry.[247] In 2016, approximately 81 million passengers processed through LAX (an 8% increase from 2015), which makes it the world's fourth busiest airport.[248] Thus, the airport is also a critical node to the global aviation transportation system. In the United States, it is ranked in the top five for

[245] Riedman, 20.

[246] Wikipedia, s.v. "Los Angeles international airport," accessed December 12, 2017, https://en.wikipedia.org/wiki/Los_Angeles_International_Airport.

[247] "Sustainability Report," Los Angeles World Airports, 11, 2016, http://www.laxsustainability.org/documents/Sustainability_Report_2016.pdf.

[248] Los Angeles World Airports, 11.

passenger throughput and fifteenth for cargo traffic, and is the nation's busiest origin and destination airport.[249] Hence, more people begin and end their trip at this airport.

LAX is the hub for Alaska Airlines, American Airlines, Delta Air Lines, and United Airlines, to name a few, and services the airlines of Southwest, Spirit, Qantas, Allegiant, New Zealand Air, and Volaris (see Appendix F for a comprehensive list).[250] In 2016, LAX provided 742 non-stop flights to 101 U.S. cities, and 1,280 flights to 77 international cities in 42 countries.[251] It serves 101 domestic and 85 international destinations to Asia, Oceania, Latin America, and Europe.[252] These locations make the airport a critical asset to worldwide market connections. LAX also provides service to cargo carriers, and in 2016, it processed 2.2 million tons of cargo shipments valued at over $101.4 billion.[253] The U.S. GDP was valued at $18.57 trillion in 2016, which pegs the LAX cargo share, alone, at 0.5% of the GDP.[254] Therefore, LAX is an important part of America's global market economy.

The Los Angeles World Airports (LAWA) is the airport operator and owner of LAX. LAWA is a government entity of the City of Los Angeles (formerly the Department of Airports) and seven members of the Board of Airport Commissioners govern it.[255] The mayor appoints the members who are approved by the city council.[256] LAWA governs the two airports of LAX and the Van Nuys Airport, as well as the business property of Palmdale (7,500 acres in the City of Palmdale), which houses the tenants of the National Aeronautics and Space Administration (NASA), County of Los Angeles, and agricultural tenants.[257]

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[249] Wikipedia, "Los Angeles international airport."

[250] Wikipedia, paragraph 4.

[251] Los Angeles World Airports, "Sustainability Report," 11.

[252] Wikipedia, "Los Angeles international airport," paragraph 4.

[253] Los Angeles World Airports, "Sustainability Report," 11.

[254] "GDP (current US$)," World Bank, accessed February 17, 2018, https://data.worldbank.org/indicator/NY.GDP.MKTP.CD.

[255] "About Los Angeles World Airports," Los Angeles World Airports, October 2015, http://www.lawa.org/welcome_LAWA.aspx?id=684.

[256] Los Angeles World Airports.

[257] Los Angeles World Airports, "Sustainability Report," 5.

LAX actively supports the local and national economy. Based on 2014 statistics, LAX generated 620,610 local jobs, $37.3 billion in labor income, $126.6 billion in economic output, and $8.6 billion in federal tax revenue.[258] LAWA directly employs about 2,500 people and according to the Los Angeles County Economic Development Corporation, it is a major economic developer for California's southern region based its on-going construction and improvement programs.[259] It is a capital economic engine. The on-going 15-year LAX modernization program is expected to finish in 2023, and by that time, "Los Angeles World Airports will have spent more than $14 billion to re-imagine, renovate and rebuild LAX."[260] This project is creating thousands of jobs for the city of Los Angeles.

Since 1974, LAX has been the target of four attacks and two attempted attacks by either IEDs or gunfire. This fact shows that the airport is an appealing target for adversaries. The incidents are as follows. In 1974, Muharem Kurbegovic killed three and injured 36 when he detonated an explosive in a locker.[261] In 1980, a homemade bomb exploded at the ticket counter of China Airlines.[262] In 1982, members of the Armenian Secret Army for the Liberation of Armenia attempted to bomb the cargo office of Air Canada. In 1999, the foiled attack of the Millennium bomber (Ahmed Ressam) revealed a plot to bomb crowded areas in the curbside and terminal landside locations using four IED luggage bombs. U.S. customs agents captured him with bomb-making material while traveling on a ferry from Canada to Washington State.[263] In 2002, gunman Hesham

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[258] Los Angeles World Airports, 11.

[259] "Study Shows Significant Positive Economic Impacts of LAX Projects and Operations," Los Angeles County Economic Development Corporation, April 21, 2016, https://laedc.org/2016/04/21/study-shows-positive-economic-impacts-lax-projects-and-operations/; Los Angeles World Airports, "Sustainability Report," 11.

[260] Los Angeles County Economic Development Corporation, "Study Shows Significant Positive Economic Impacts," paragraph 5.

[261] Donald Stevens et al., *Near-Term Options for Improving Security at Los Angeles International Airport* (Santa Barbara, CA: RAND, 2004), 1, www.rand.org/content/dam/rand/pubs/documented.../2004/RAND_DB468-1.pdf.

[262] Shelby Grad and Richard Winton, "Before Brussels, LAX Was Repeatedly a Target of Terrorism," *Los Angeles Times*, March 22, 2016, http://www.latimes.com/local/lanow/la-me-ln-before-brussels-lax-was-target-of-terrorism-20160322-story.html.

[263] "Ahmed Ressam's Millennium Plot," PBS, accessed January 12, 2017, https://www.pbs.org/wgbh/pages/frontline/shows/trail/inside/cron.html.

Hadayet opened fire in the crowded ticket check-in counter of El Al airlines and killed two and injured four.[264] In 2013, a gunman opened fire in the TSA passenger-screening checkpoint queue and terminal, killed a TSA officer, and injured two other TSA officers and a passenger.[265] These multiple attacks and foiled plots illustrate the attractiveness of the airport as a target and the vulnerability of crowded places in the terminals.

2. Synopsis of Attack Event

Paul Anthony Ciancia, an unemployed car mechanic, was 23 years old when he took the life of TSA Officer Gerardo I. Hernandez and injured three others.[266] Ciancia was a native of New Jersey and had lived in Los Angeles only 18 months before executing the attack. On the morning of November 1, 2013, Cianca requested his roommate drive him to the airport to visit his family in New Jersey.[267] His roommate, who was unaware of his intentions, dropped him off at the airport's curbside. The assailant entered the public landside of Terminal 3. At approximately 9:20 AM, the attacker removed the semiautomatic rifle from his luggage and opened gunfire in the entrance of the TSA pre-check passenger-screening checkpoint queue. He fired several rounds at point-blank range at TSA Officer Hernandez as he was checking travel documents at the beginning of the queue.[268] The attacker continued up the escalator (see Figure 14), and upon seeing Officer Hernandez move, returned to discharge more rounds into the officer. He fired a total of 12 times into the victim's body.[269]

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[264] Stevens et al., *Near-Term Options for Improving Security at Los Angeles International Airport*, 1.

[265] Stevens et al., 1.

[266] Matt Hamilton, "LAX Shooter's Plea Agreement Reveals He Did Not Consider Himself a Terrorist, but a 'Patriot'," *Los Angeles Times*, September 1, 2016, http://www.latimes.com/local/lanow/la-me-ln-lax-shooter-guilty-plea-20160901-snap-story.html; Kate Mather, Matt Stevens, and Ashley Powers, "LAX Shooting: Gunman Wanted to Kill Several TSA Agents, Complaint Says," *Los Angeles Times*, November 3, 2013, http://www.latimes.com/local/lanow/la-me-ln-lax-shooting-gunman-kill-tsa-agents-20131103-story.html.

[267] Hamilton, "LAX Shooter's Plea Agreement," paragraph 4.

[268] Los Angeles World Airports, *Active Shooter Incident and Resulting Airport Disruption, A Review of Response Operations* (Los Angeles: Los Angeles World Airports, 2014), 2, http://www.activeshooter test.com/wp-content/uploads/2015/07/LAWA-T3-After-Action-Report-March-18-2014.pdf.

[269] U.S. District Court for the Central District of California, *Plea Agreement for Defendant Paul Anthony Ciancia*, No. CR 13-902-PSG (Los Angeles: U.S. District Court for the Central District of California, 2016), 29, www.courthousenews.com/2016/09/06/LAX.pdf.

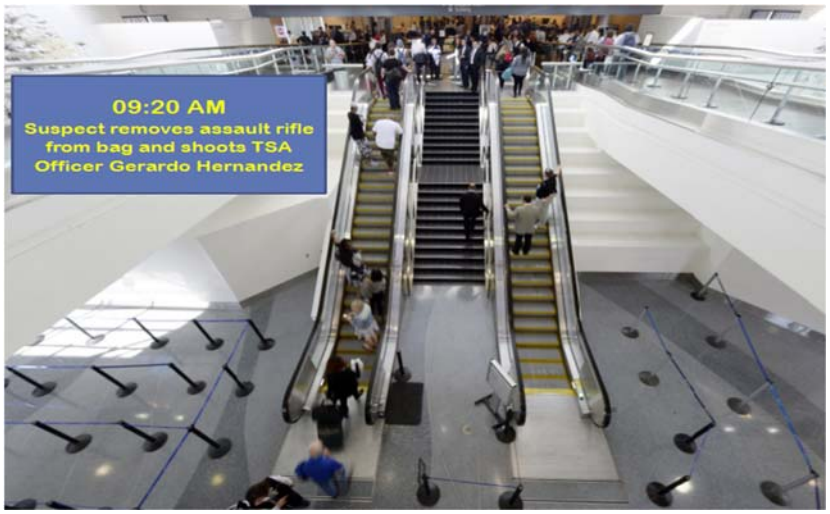

Figure 14. Escalators to Proceed to TSA Screening Checkpoint.[270]

The attacker went up the escalator toward the TSA screening checkpoint. People in the immediate area who saw the assailant or heard the gunshots dispersed and either fled, hid, or lay on the floor. The assailant proceeded past the screening checkpoint exit lane and bypassed dozens of individuals hiding or lying on the floor. He proceeded into the terminal where he asked people if they were with the TSA. As he continued down the concourse, he shot and injured an airline passenger and two additional TSA officers.[271] An estimated 1,000 individuals were in the terminal during this time.[272]

The police received emergency calls at 09:20 AM and immediately dispatched officers to the area. Officers from the LAWAPD, Los Angeles Police Department (LAPD), and Customs and Border Protection (CBP) converged on the scene. The officers controlled, assessed exit and egress zones, and pursued the assailant. The order was given at 09:24 AM to close all roadways and lock down airfield access posts.[273] The assailant

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[270] "Active Shooter Incident and Airport Disruption, After Action Review," Los Angeles World Airports, March 18, 2014, lawa.granicus.com/MetaViewer.php?view_id=4&clip_id=156&meta_id=15757, slide 10.

[271] "LAX Shooting Suspect Reportedly Told Police He Acted Alone," Fox News, paragraph 21, November 4, 2013, http://www.foxnews.com/us/2013/11/04/lax-shooting-suspect-reportedly-told-police-acted-alone.html.

[272] Patrick Gannon, email communication to Deputy Executive Director, Public Safety and Security for LAX, January 7, 2017.

[273] Los Angeles World Airports, *Active Shooter Incident and Resulting Airport Disruption*, 8.

was engaged at approximately 09:25 AM and shot four times by police officers near concourse Gate 35 inside the secure area of the terminal (see Figure 15). According to the LAWA *After Action Review*, the event was over in four minutes and eight seconds.[274]

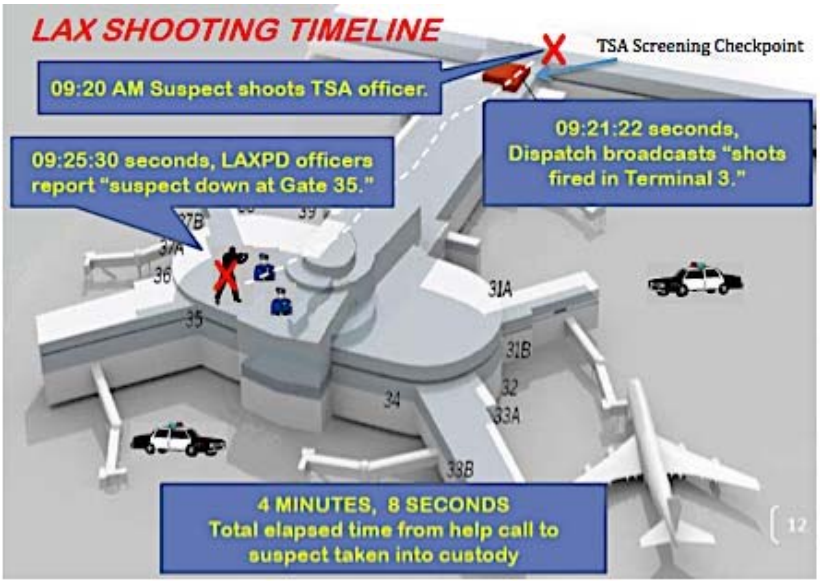

Figure 15. Sequence of LAX Shooting Event.[275]

Before 08:00 AM on the day of the event, Ciancia wrote two long text messages to his brother and sister. He wrote to his brother; "All of my life was just training for this day. In fact it was a very rigorous training course to make me strong enough for this job, so I wouldn't hesitate in the moment of truth… this was the purpose I was brought here."[276] To his sister he quoted Thomas Jefferson and the power of private banks. He wrote, "I don't want your kids to grow up in a totalitarian state… There wasn't a terrorist attack on Nov 1. There was a pissed off patriot trying to water the tree of liberty."[277] It is

[274] Los Angeles World Airports, "Active Shooter Incident and Airport Disruption, After Action Review," slide 12.

[275] Adapted from Los Angeles World Airports, slide 10.

[276] U.S. District Court for the Central District of California, *Plea Agreement for Defendant Paul Anthony Ciancia*, 27–28.

[277] U.S. District Court for the Central District of California, 28.

apparent based on these comments that Ciancia had a political and conscious motive for the attack.

Ciancia's planning and attack preparations were discovered in his plea agreement.[278] In a federal criminal complaint affidavit from the Central District of California, FBI Special Agent Stephen J. Khoobyarian provided the evidence that the assailant was carrying a handwritten letter that showed he had "'made the conscious decision to try to kill' multiple TSA employees" and wanted to "instill fear in your [TSA employees] traitorous minds."[279] Ciancia's letter, transcribed in the plea agreement, referenced the conspiracy totalitarian group *New World Order* and the ease of bringing a firearm into the airport.[280] The letter reveals his perceptions of an opportunity for attack in the public terminal area. Ciancia stated in his letter:

> I want it to always be in the back of your head just how easy it is to take a weapon to the beginning of your nazi checkpoints. If you want to play that game where you pretend that every American is a terrorist, your going to learn what a self-fulfilling prophecy is" [underline in document].[281]

Ciancia was very explicit in his letter about his hatred toward the government and he used derogatory language to reference Janet Napolitano (former DHS Secretary). The language used in his writing clearly demonstrates his intentions and perceptions about the ease of attack. It was also evident that Ciancia wanted the letter to be found because he placed it in the luggage he brought into the airport and the police discovered it after the attack.[282]

The attacker premeditated the murders and prepared for the event several months in advance by purchasing an assault rifle and ammunition from a licensed gun dealer.[283]

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[278] U.S. District Court for the Central District of California; Hamilton, "LAX Shooter's Plea Agreement."

[279] "Federal Criminal Complaint against Paul Anthony Ciancia," *Los Angeles Times*, 4, November 2, 2013, http://documents.latimes.com/federal-criminal-complaint-ciancia/.

[280] Fox News, "LAX Shooting Suspect Reportedly."

[281] U.S. District Court for the Central District of California, *Plea Agreement for Defendant Paul Anthony Ciancia*, 26.

[282] Mather, Stevens, and Powers, "LAX Shooting," paragraph 2. Police recovered the note at the crime scene.

[283] Fox News, "LAX Shooting Suspect Reportedly Told Police He Acted Alone," paragraph 21.

On the day of the attack, Ciancia carried a duffle bag packed with a semiautomatic rifle (.223-caliber Smith & Wesson M&P-15), 10 rifle magazines, 500 rounds of ammunition, wore dark clothing, and a bulletproof vest.[284] He had purchased the materials within eight to six months before the attack.[285] He admitted in his court testimony to modifying the two pieces of luggage "by cutting matching rectangular holes"[286] and "zip-tying them together to conceal" the loaded semi-automatic assault rifle.[287] He specifically targeted TSA officers because as he moved through the airport terminal he questioned individuals if they were with the TSA, and if they said no, he continued walking.[288] These actions demonstrated his direct and conscious willingness to target government employees. The airport environment and design presented him an opportunity to carry out his plan because he was able to navigate easily to the sterile area with weapons.

The news media and other reports suggest that Ciancia may have suffered from mental illness. The news reports indicated that the assailant wanted to attack TSA officers in a suicide attempt.[289] However, based on his letter and text messages, it appears that Ciancia attacked the TSA because he felt hatred toward the government and he perceived the TSA as an easy target. Former classmates described him as having a speech impediment, being a loner, and quiet, but there is no evidence of a prior history of mental

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[284] U.S. Department of Justice, "California Man Pleads Guilty," paragraph 8; "LAX Gunman Charged, Carried Note Saying He Planned to Kill 'Multiple' Agents," *Journal*, November 3, 2013, http://www.thejournal.ie/lax-shooting-gunman-charged-tsa-agent-1158539-Nov2013/; Mather, Stevens, and Powers, "LAX Shooting," paragraph 7.

[285] U.S. Department of Justice, "California Man Pleads Guilty in 2013 Shooting Spree at Los Angeles International Airport and Admits to First-Degree Murder of Transportation Security Administration Officer," press release, paragraph 8, September 6, 2016, https://www.justice.gov/opa/pr/california-man-pleads-guilty-2013-shooting-spree-los-angeles-international-airport-and-admits; Hamilton, "LAX Shooter's Plea Agreement," paragraph 10.

[286] U.S. District Court for the Central District of California, *Plea Agreement for Defendant Paul Anthony Ciancia*, 1.

[287] U.S. Department of Justice, "California Man Pleads Guilty," paragraph 8; U.S. District Court for the Central District of California, 26.

[288] U.S. Department of Justice, paragraph 9.

[289] Jonathan Allen, "Suspected L.A. Airport Gunman Planned 'Suicide' Mission: Congressman," *Reuters*, November 2, 2013, https://www.reuters.com/article/us-usa-california-airport/suspected-l-a-airport-gunman-planned-suicide-mission-congressman-idUSBRE9A00RS20131103; Samantha Tata and Kim Baldonado, "Alleged LAX Gunman Spoke of Suicide before Shooting," NBC Southern California, November 2, 2013, https://www.nbclosangeles.com/news/local/Paul-Anthony-Ciancia-LAX-Shooting-Suspect-Los-Angeles-Airport-TSA-230289841.html.

diagnosis or treatment.[290] Some experts surmise that even though no evidence of past mental illness was seen, he may have begun to fall into a deteriorating mental health state because he had sent alarming text messages to his family. Ciancia's attorneys considered a mental health defense but it was not argued in the case.[291]

On August 30, 2016, the assailant pled guilty to 11 felony counts and was charged with the federal offence of first-degree murder and committing violence at an international airport. Additionally, he was charged with "using a firearm to murder and cause death."[292] Federal prosecutors had initially called for capital punishment due to the "substantial planning and premeditation" that went into the attack; however, they agreed not to seek the death penalty in exchange for life-without-parole in prison.[293]

It is important to note that Ciancia prepared for the attack in advance. This fact demonstrates that he must have conducted some pre-surveillance of the airport terminals before he initiated the attack. His perception that it is easy to bring a weapon to the "beginning" of a checkpoint signifies that effective deterrence measures were not in place. The amount of ammunition he carried also signifies that he intended to cause massive harm. The inability to detect someone with such massive amounts of firepower in a critical infrastructure building is alarming. The risk of attack toward the public in a large airport is high because the airport environment houses so many people (adults and children). This scenario exemplifies the need to initiate change in these landside areas of the airport. The impact of the attack event is examined in the following section.

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[290] Snejana Farberov, "LAX Gunman Planned to Die in Shoot-out With 'Pigs and the TSA' Who He Ranted About in Suicide Note He Took on Deadly Rampage," *Daily Mail*, November 2, 2013, http://www.dailymail.co.uk/news/article-2483833/LAX-airport-shooter-Paul-Anthony-Ciancia-ranted-killing-pigs-TSA-pictured.html; Doug Gross, "Sources: Alleged Shooter Hated Government, 'New World Order'," CNN, November 3, 2013, https://www.cnn.com/2013/11/01/us/lax-shootings-suspect/index.html.

[291] "Defense Indicates Mental Issues May Be Raised at Trial of LAX Shooter," *Los Angeles Daily News*, August 28, 2017, https://www.dailynews.com/2015/02/10/defense-indicates-mental-issues-may-be-raised-at-trial-of-lax-shooter/.

[292] "Federal Grand Jury Indicts LAX Shooting Suspect," CNN, paragraph 4, December 17, 2013, http://www.cnn.com/2013/12/17/travel/lax-shooting-indictment//; Mather, Stevens, and Powers, "LAX Shooting."

[293] Hamilton, "LAX Shooter's Plea Agreement," paragraph 4; U.S. Department of Justice, "California Man Pleads Guilty," paragraph 6; U.S. District Court for the Central District of California, *Plea Agreement for Defendant Paul Anthony Ciancia*, 26.

3. Attack Impact on Security

The active shooting event at LAX on November 1, 2013 caused substantial disruption to aviation transportation and LAX's operations. The LAWAPD and LAPD conjointly secured the terminal and crime scene, and the Los Angeles Fire Department (LAFD) cordoned off the east side of Terminal 2 for a street-side triage area.[294] All passengers and employee personnel were directed to evacuate the building. According to the LAWA *Active Shooter Incident* report, "the evacuation of Terminal 3 also triggered the spontaneous evacuation of Terminals 1 and 2," which resulted in halting aircraft and displacing thousands of passengers throughout the airports' airside and landside.[295] The spontaneous evacuation from the other terminals was an unexpected event for the airport authorities.

The evacuees of the incident included airport employees, passengers, TSA officers, airline employees, and the general public who were picking up or dropping off passengers.[296] The evacuees were directed to the Tom Bradley International Terminal (TBIT) for witness collection. At 09:32 AM, the incident command post (ICP) was established, and at 9:48 AM, the Department Operations Center was initiated. The order was given by LAWAPD to shut down all air traffic operations at 10:03 AM. Due to the buildup of aircraft on the runways, the FAA concurred with a ground stop for all LAX arrivals.[297] This ground stop resulted in diverting hundreds of incoming and outgoing aircraft. During this time, vehicle parking structures, Terminal 3, and the airfield were also cleared for any additional or possible threats.

According to the LAWA *Active Shooter Incident and Resulting Airport Disruption* report, the active shooting event of 2013 "triggered one of the largest multi-jurisdictional law enforcement operations in the Los Angeles region" where it "had

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[294] Los Angeles World Airports, *Active Shooter Incident and Resulting Airport Disruption*, 9.

[295] Los Angeles World Airports, 60.

[296] "Shooting Rampage at Los Angeles: How It Happened," YouTube video, 7:21, posted by ABC News, November 1, 2013, https://www.youtube.com/watch?v=XZZD4TAn644.

[297] Los Angeles World Airports, *Active Shooter Incident and Resulting Airport Disruption*, 9.

cascading effects that rippled across the airport for the better part of two days."[298] The event impacted 171,000 passengers and 1,500 flights "disrupting the operations of the entire air transportation system."[299] More than 20,000 people were confined in the airport terminal or onboard aircraft, where they sheltered in place or waited up to six hours to be released.[300] Many fled to the airfield, concourse area, or hid in stores, restrooms, closets, and other enclosed spaces, and an additional 4,500 people self-evacuated.

The event resulted in a complex response to direct the masses and created a significant challenge for law enforcement, emergency management, and business continuity programs.[301] The report recognizes that "airports are a particular challenge in comparison to other large facilities in that most people, when the daily population is at its peak, are transients who do not know the airport well, if at all, and must be guided or even assisted in any directed or spontaneous evacuation."[302] Since LAX has numerous international and first time travelers, the task of orienting the passengers in this large airport is daunting.

LAWA and the local government assented that the overall response was a success. As demonstrated by the after action report, however, many lessons remained to be learned for effective prevention and response strategies. The main challenges centered on prevention, public and mass notification, terminal evacuation, crowd management control, response and recovery, and a "whole community" holistic response for business continuity.[303]

Response and recovery lasted nearly 30 hours and the airport re-opened at 04:00 PM, with the exception of Terminal 3, which re-opened on November 2 at 01:05 PM. Of the 1,550 flights scheduled, 86 were diverted, 252 were cancelled, and 74 were

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[298] Los Angeles World Airports, *Active Shooter Incident and Resulting Airport Disruption*, 1.

[299] Los Angeles World Airports, 1.

[300] Los Angeles World Airports, 63.

[301] Los Angeles World Airports, 2, 8, 68.

[302] Los Angeles World Airports, 60.

[303] Los Angeles World Airports, "Active Shooter Incident and Airport Disruption, After Action Review," slide 21.

delayed.[304] Motor vehicle traffic was also congested because travelers and people continued to arrive to the airport to pick-up passengers. This congestion also made it difficult for emergency and first responders to navigate to needed areas. The impact of this event demonstrates how an attack to the airport significantly impacts aviation and other modes of transportation. Furthermore, the configuration and layout of the airport impacts crowd management, response, and recovery. Deterrence and attack prevention strategies are also crucial to consider in the airport's layout. These elements are examined in the following section.

4. Airport Configuration and Design

LAX has a total of nine terminals and 128 gates. The terminals are identified by the numbers 1, 2, 3, 4, 5, 6, 7, and 8, and the Tom Bradley International Terminal TBIT (see Appendix F). They are constructed in a U pattern, where Terminals 1 to 3 are parallel to terminals 4 to 8, and TBIT is at the curvature end of the airport. The terminal structures are physically separated from each and comprise a landside and airside location with one TSA security-screening checkpoint in each.

The airport has a two-level roadway. The parking structures and vehicle road access are located in the middle of the U pattern. Each terminal structure has three levels: arrivals, airline check-in, and departures gate level.[305] Arrivals and baggage claim are on the lower level, airline check-in counters are on the second level and departure gates and security screening on the upper level. Some TSA passenger queues begin in the second level and the passengers move up escalators to the upper level to process through checkpoint screening. Passenger drop-off and pickup zones are at the terminal curbside; however, parking or waiting is not permitted.[306]

Shops, restaurants, lounges, and bars are mainly located in the secure side of the terminals, which is good because it limits the amount of crowds that can form in the

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[304] Los Angeles World Airports, slide 17.

[305] "LAX Map and Gate Information," LAX Airport Parking Lot, 2018, http://www.laxairportparking lot.com/lax-parking-airport-information/.

[306] "Smart Traveler Tips—English," Los Angeles World Airports, November 2015, https://www.fly lax.com/lax-guides-tips-and-amenities.

public areas due to shopping. Only five restaurants are located in the departures landside level of TBIT, and one coffee shop in the arrivals landside level in Terminal 6 (located before the security checkpoints).[307] With the exception of TBIT, the public space of the terminal areas is narrow and resembles a large hallway. The slender design causes congestion of people in ticking check-in counters and queuing areas; thereby, causing crowds to form and increasing vulnerability from attack.

Passengers transit between terminals 1, 2, and 3, and TBIT by shuttle buses in the airport's landside; therefore, passengers need to be re-screened through the TSA security checkpoints to re-enter the terminals. The need to re-screen passengers causes an increase of people in the public terminal spaces and TSA queuing areas. Underground tunnels, above walkways, and airside bus shuttles in the secure side interconnect terminals 4 to 8 and TBIT (see Appendix F).[308] Passenger crowds are not as vulnerable to attack in these areas because they have already been screened for prohibited items. If such a similar system for terminals 1, 2, and 3; it would contribute to minimizing the crowds in the non-sterile areas.

The airport also connects to other modes of transportation, such as the bus services and the metro rail. Main routes of several bus systems connect at the LAX transit center, (located in the airport's Lot C parking), where a shuttle transports people to the airport terminals. LAWA offers scheduled bus service to downtown Los Angeles, Hollywood, Long Beach, San Fernando Valley, and Westwood to LAX.[309] Additionally, the "G" shuttle bus connects people from the airport to the Los Angeles Metro Rail Green Line. Multiple modes of transportation connect at the airport and are interdependent on each other for the efficient functionality of the airport. Therefore, an impact to any one of these modes will considerably impact the entire transportation system because they are interconnected to each other.

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[307] "Dining & Shopping," Los Angeles World Airports, 2017, https://www.flylax.com/lax-dining-and-shopping.

[308] Wikipedia, "Los Angeles international airport."

[309] "LAX Flyaway," Los Angeles World Airports, 2017, https://www.flylax.com/flyaway.

Plans are underway to build the *automated people mover system* (LAX train) to the rail transportation system. The LAWA's goal is to relieve traffic congestion in the central terminal area due to the increasing number of passengers departing from LAX. This new system will feature six new stations that will connect to the rental car center, metro, airport parking, and airline terminals.[310] The projected completion of the project is in 2023.[311]

In LAX, crowds easily form due to the magnitude of passengers who depart from this airport and the multiple modes of transportation that bring people to this airport. The airport layout reveals that some terminals are not interconnected on the secure side. Hence, passengers on connecting flights (domestically and internationally) may need to exit the secure side of one terminal to be re-screened to enter another. This type of configuration increases passenger movement to the public terminal non-secure landside, which is accessible to the general public. The passenger flow also increases the probability of crowds in these areas and TSA checkpoint queues. Therefore, vulnerability to attack capacity and risk is increased.

5. Case Analysis: LAX

At approximately 1,100 sworn and civilian members, LAX has one of the largest police forces serving the airport.[312] The *Active Shooter Incident after Action Review* by the Board of Airport Commissioners, as well as the *Active Shooter Incident and Resulting Airport Disruption*, report holds that LAX has an enhanced and extensively trained police presence, including high visibility to provide deterrence, perimeter and airfield mobile patrols, checkpoint patrols at entry points, bicycle patrols, and plainclothes operations.[313] One characterization of findings from the report was that "immediate tactical response by Airport Police was swift, heroic, and well-executed as a result of prior active shooter

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[310] "The Solution," Los Angeles World Airports, 2014, https://www.lawa.org/en/lawa-landside-access-modernization-program/solution.

[311] "Anticipated Process and Schedule," Los Angeles World Airports, 2014, http://www.connectinglax.com/process.html.

[312] Los Angeles World Airports, "Active Shooter Incident and Airport Disruption, After Action Review," slide 6.

[313] Los Angeles World Airports, slide 7.

training."[314] However they claim, "had the attacker not been highly selective in his targets, and/or had there been multiple attackers with weapons of greater lethality, the outcome might have been far different."[315] This claim raises the question as to why the 2013 shooter perceived that it was easy to bring weapons and attack people in the terminal.

On the day of the attack, the news media reported that no outward police presence was located in the vicinity of the attack and that "the two airport police officers assigned to Terminal 3 where out of position."[316] Police presence in the entrance to the TSA queue was scarce and the initial call to 911 came from a contracted service worker.[317] The presence of police, which is an environmental perceived deterrent factor, is crucial to how adversaries conduct surveillance and planning. As a response to police patrol practices, the LAWA *Active Shooter Incident* report claims that "LAWAPD has implemented random police patrol and show-of-force tactics designed to continually change the face of police presence at LAX and make attempts at pre-attack surveillance."[318] It implemented the random action measures (RAMs), which is a team of conjoint canine and police geared toward patrolling populated areas "to provide a sudden high visibility police presence at any place or time."[319] The report does not specify, however, whether these units are specifically created to guard crowds or provide presence when crowds actually form. Also, it is not clear whether these units will focus their efforts on the public landside of the airport terminals. These areas are crucial because of public access and the pre-surveillance activities of adversaries.

A joint public safety review by LAWAPD, LAPD, and LAFD concluded that the following five issues must be addressed and improved at LAX based on the lessons

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[314] Los Angeles World Airports, slide 20.

[315] Los Angeles World Airports, "Active Shooter Incident and Resulting Airport Disruption," 15.

[316] "Cops Took 1.5 Hours to Organize Response to LAX Shooting," *Associated Press*, March 18, 2014, https://nypost.com/2014/03/18/cops-took-1-5-hours-to-organize-response-to-lax-shooting/.

[317] California State Assembly, "Active Shooter LAX Hearing 2-28-14," 11, accessed December 30, 2017, assembly.ca.gov/sites/assembly.ca.gov/files/Active%20Shooter%20LAX.pdf.

[318] Los Angeles World Airports, "Active Shooter Incident and Resulting Airport Disruption," 13.

[319] Los Angeles World Airports, 13.

learned from the event: 1) "prevention and preparedness," 2) "incident detection and notification," 2) "use of video surveillance," 3) "police and EMS capabilities," 4) "radio communications interoperability," and 5) "emergency evacuation of airport terminals."[320] Additionally, special consideration was given to prevention and protection activities by accepting a practice to randomize police patrols, screen vehicles at checkpoints, use CCTV, and perform tactical response operations.[321] In essence, these strategies increase surveillance as prescribed by CPTED principles.

The report recommends placing a premium on *security design* through a layered approach of incident prevention. Regarding airport environmental design, they proclaim that *single points of failure* can be evaded by employing a security strategy that follows "a defense-in-depth mindset, where all parts have a layered and interdependent security program (intelligence, civilian engagement, CCTV and alarms, communications, command and control, and operation, etc.) [and] are integrated in concentric rings around the airport and its most critical elements."[322] These components need to incorporate scalable and adaptable well-integrated architectural security systems to the emerging threat. The fundamental goal would be to create an environment that provides a more permanent threat aversion strategy. Whereas randomized police and canine patrols are mobile and may provide deterrence to an adversary's pre-attack surveillance, environmental design provides a robust, sustainable, reliable, and enduring method to the layered approach to security. These measures were lacking at the time of the active shooter event. Also, as demonstrated by the incident, police were not present in the vicinity of the attack. The randomness of police patrols may leave an open gap in an area where an adversary is seeking to cause harm. This gap can be closed by environmental security design countermeasures.

On the day of the active shooter event, people in the terminal fled, hid, or found other "forms of cover."[323] Mather, Stevens, and Powers attest that "some travelers

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[320] Los Angeles World Airports, "Active Shooter Incident and Resulting Airport Disruption," 13.

[321] Los Angeles World Airports, 13.

[322] Los Angeles World Airports, 14–15.

[323] Los Angeles World Airports, 8.

ducked behind planters and advertising kiosks to avoid gunfire."[324] This response demonstrates that the environment must not only obstruct people from running, but also, that some type of heavy protection is warranted. Large, heavy planters would be one good option to shield or minimize gunshots that may mimic the bullet effect of sandbags around bunkers. Thus, considering these types of environmental features, materials, or objects similar to these planters may provide options for mitigation.

A RAND corporation study in 2004 specifically addressed LAX airport's near-term terrorism security counter-measures and improvements.[325] Most of the findings prove relevant to the present day. Steven's et al. attest to the fact that, "in meeting the terrorist threat, we find that the problem is how to influence behavior of an unpredictable enemy," and that "the solution is to shape the situation so that in any scenario the outcomes from the terrorist's point of view will be unsatisfactory."[326] The RAND infrastructure, safety, and environment unit analyzed 11 major classes of attacks, which include the following:

- Large truck bomb
- Curbside car bomb
- Luggage bomb
- Uninspected cargo bomb
- Insider-planted cargo bomb
- Air operations attack
- Public grounds attack
- Air traffic control tower/ utility plant bomb

[324] Mather, Stevens, and Powers, "LAX Shooting," paragraph 2. Police recovered the note at the crime scene (paragraph 11).

[325] Stevens et al., *Near-Term Options for Improving Security at Los Angeles International Airport*.

[326] Stevens et al., vii.

- Man portable air defense system (MANPADS) attack
- Sniper attack
- Mortar attack[327]

Their extensive research found that what is most important is not the size of the bomb but the location where it is discharged. They concluded based on the various scenarios examined that "all of the most dangerous terrorist attacks involve terrorist placing a bomb in close proximity to a vulnerable crowd of people."[328] They attest that the "keys to achieving both deterrence and damage limitation are *controlling and reducing vulnerability*" (authors' emphasis).[329] This change not only diverts terrorists away from LAX, but it also creates a situation where they do not have good options.

In studying the crowded terminal spaces, the RAND study found that upwards to 400 people wait in line at airline check-in counters.[330] Crowds appear even larger in LAX's landside terminal because the space is designed in a narrow elongated shape. Peak passenger loads also occur concurrently throughout the airports' terminals, thereby maximizing potential target locations and multiple attacks. This targeting indeed was the intention of the Millennium bomber's uncovered plot, as discussed earlier. His intention was to detonate multiple luggage IEDs in LAX's passenger queuing areas.

In a more recent 2012 RAND report, the authors propose that VBIEDs, multi-stage bombings, and armed assault are reasonable incremental innovations of the current threat picture.[331] A few of their recommendations included improving airport processes, acquiring new technology, and building new construction for infrastructure protection, which are comparable to the recommendations of the *LAWA After Action Report*. The

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[327] Stevens et al., *Near-Term Options for Improving Security at Los Angeles International Airport*, viii–ix.

[328] Stevens et al., x.

[329] Stevens et al., 11.

[330] Stevens et al., 22.

[331] Jackson et al., *Efficient Aviation Security*, 36–37.

RAND researchers posit that, "reducing the density of people in terminals appears to be the most cost-effective because it is both very effective and inexpensive."[332]

How may bomb protection for soft targets impact attack scenarios that involve gunfire? Although unique environmental design basics must be considered in minimizing explosive impact for crowd protection, some similar and overlapping benefits can also be applied to active shooter cases. These benefits include minimizing crowds or the appearance of crowds, increasing the risk in crowd attack, and minimizing environmental debris from gunfire and impact. These design basics would incorporate the same blast resistant and hardening infrastructure material needed for a blast impact. Additionally, shielding material, such as the heavy planters or comparable structures, would provide both IED shock absorption and disruption and gunfire absorption mitigation. In the active shooter scenarios, careful consideration should also be given to how the crowd or people will escape from the threat. Environmental limitations must also be assessed to not impede this movement.

Active shooter environmental designs have continued to develop since incidents such as the 2012 Sandy Hook mass shootings.[333] Smith and Renfroe recommend conducting American Society of Industrial Security (ASIS) facility risk assessments by a certified physical security professional or certified protection professional. They recommend implementing the CPTED principles of natural surveillance, such as CCTV cameras, door locks, turnstiles, badges, and securing passageways.[334] They also emphasize early detection systems, such as alarms. Often, the challenge during active shooting events is that occupants of the building may not hear or recognize the sound of gunfire. Indeed, after the event at LAX, the TSA took a national approach to install duress alarms at all screening checkpoints as a response to the lessons learned from the event. A process for immediate mass notification to personnel and authorities is key for

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[332] Stevens et al., *Near-Term Options for Improving Security at Los Angeles International Airport*, 40.

[333] Kelsey Atherton, "Landscape Architects Now Design for Mass Shootings," *Verge*, October 13, 2017, https://www.theverge.com/2017/10/13/16467716/mass-shootings-science-survival-studies-terrorism-crowds.

[334] Joseph L. Smith and Daniel R. Renfroe, "Active Shooter: Is There a Role for Protective Design?," Applied Research Associates, Inc., August 2, 2016, https://www.wbdg.org/resources/active-shooter-there-role-protective-design.

threat elimination. Unlike the impacts of an IED, active shooters are often mobile and seconds save lives in extinguishing the threat.

As described previously in the LAX airport and configuration section, LAWA is undertaking a massive reconstruction and improvement plan for the airport infrastructure. In fact, a dedicated LAWA site is available for airport construction planning and alerts, community information, and information about the modernization program. The *2017 Design and Construction Handbook—Airport Structural Design Standards* describes LAWA's goals for airport infrastructure builds and structural standards.[335] This recent document provides the basis for seismic and structural design measures for new builds. On a positive aim, *Design Standards* consider performance-based engineering (PBE) and "code based prescriptive methodology, using an increased importance factor."[336] These factors include adhering to the governing code authority and "assessment of the building's seismic force resisting systems."[337] Although the document does not specifically address how to design for the protection of crowded spaces, IEDs, or active shooters, it does describe the seismic potential of non-structural systems, such as mechanical ducts, cables, shelving, cabinets, glazing, partitions, electrical lighting, vending machines, billboards, artwork, etc., which can create debris from an active attack.[338] Parking structures, vehicle impact bollards, and passenger boarding bridges are also considered for jet blast loading and strength. These components are essential to consider for blast fragment protection and gunfire mitigation.

6. Implications of Airport Design

It was evident that the gunman in the 2013 attack believed that the airport checkpoints were easy targets and that he had prepared for the event. If the TSA passenger queue was not as easily accessible, or if he believed he would not be

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[335] Los Angeles World Airports, *Airport Structural Design Standards* (Los Angeles: Los Angeles World Airports, 2017), http://www.lawa.org/uploadedFiles/LAXDev/DCH/2017/Design_Stds/Airport%20 Structural%20Design%20Standards%20July%202017.pdf.

[336] Los Angeles World Airports, 1.

[337] Los Angeles World Airports, 1.

[338] Los Angeles World Airports, 2.

successful, then he may not have entered this area. For example, turnstiles that allow passengers with boarding passes to access a security checkpoint can provide this additional layer. The TSA officer was shot at the beginning of the passenger queue as he was checking boarding passes. A layered approach to access control, such as using turnstiles then establishing an area to verify identity, would have established a delay and possibly prevented the intruder from accessing this area. In essence, if the attacker had pre-surveilled the area, he would have surmised that it would have been difficult for him to access this area, hence, causing deterrence.

The crowd in the TSA checkpoint dispersed due to the close proximity of the sound of gunfire. Environmental technology built to detect gunfire sounds or detect gunpowder is an option in productive countermeasure for active shooter events. Building alarms set to initiate during an active shooter event would notify the individuals in the entire building, as well as police. Additionally, this would have been an effective countermeasure for mass notification. Unlike the suicide bomber or IED explosion, which is localized, the threat from an active shooter is mobile. In other words, the threat is not extinguished until the active shooter is immobilized and disarmed, which requires a different element of engagement and response. Environmental design proposals for effective active shooter mitigation are provided in the Chapter IV.

LAX is in the beginning phases of its multi-billion re-construction project. Since critical infrastructure blast-resistant measures are sensitive security information in the United States, specific details are not published to the general public. However, LAWA is currently planning to incorporate CPTED principles, as well as mitigate threats through environmental design. For example, they have hired firms in architectural security design to conduct threat and vulnerability assessments (TVA).[339] The evaluations identify vulnerabilities and provide the airport the ability to challenge designers and builders to mitigate these issues. Additionally, public safety and security committees have been formed to address industry best practices. These groups are considering renovations, such as placing "security desks" in the public area of the terminals.[340] These desks provide

[339] Pat Gannon, telephone communication with author, January 12, 2017.

[340] Pat Gannon, telephone communication with author, January 12, 2017.

deterrence measures because they are directly visible by the public as soon as they walk into the terminal. In the United States, a systematic approach to airport design using CPTED is beginning to emerge. Industry leaders are starting to consider how environmental design elements can be incorporated to protect people in the public spaces of the airport.

C. GLASGOW

The Glasgow International Airport authorities' response to the terrorist attack on June 30, 2007, provides valuable best practices to mitigate threats on soft targets. The industry leaders have implemented innovative environmental design strategies to protect crowds and the airport infrastructure. The proceeding comprehensive case study examines the terrorists' perception of opportunistic attack, intent, and background. The airport's configuration and layout, before and after the attack, are analyzed for security effectiveness. In conclusion, implications drawn from this study emulate approaches for other airports to follow.

1. Airport Description and Relevance

Glasgow International Airport (GLA) is located in the United Kingdom and is Scotland's second-busiest airport. Originally the Royal Air Force Station headquarters, Glasgow airport was re-built and opened to commercial aviation in 1966.[341] It is situated about nine miles west of Glasgow city.[342] GLA is vital to Scotland's prosperity because it supports more than 7,300 jobs and provides around £200 million annually to the local economy. As of 2017, Glasgow served approximately 9.9 million passengers (a 5.8% annual increase) and nearly 13,033 tons of cargo per year.[343] Thirty airlines operate in the airport and serve 120 destinations per year.[344] The Royal Air Force also continues to

[341] Wikipedia, s.v. "Glasgow airport," last updated February 28, 2018, https://en.wikipedia.org/wiki/Glasgow_Airport#cite_note-40.

[342] Wikipedia; "About Us," Glasgow Airport, accessed November 22, 2017, https://www.glasgowairport.com/corporate/about-us/.

[343] "Media Centre," Glasgow Airport, January 2018, https://www.glasgowairport.com/media-centre/a-record-99-million-passengers-make-2017-glasgow-airports-best-ever-year/; Glasgow Airport, "About Us."

[344] Glasgow Airport, "About Us."

operate aviation flight school training at the airport.[345] As the United Kingdom's eighth busiest airport with one main runway, Glasgow serves as the "principal transatlantic and direct long-haul entry airport in Scotland," thereby connecting travelers and commerce to the rest of Europe and the world.[346] This entry point demonstrates the significance of GLA's geopositioning and its impact to the local and national marketplace.

The AGS Airports Limited have owned GLA since 2014, which is a partnership between Ferrovial and Macquarie Infrastructure and Real Assets.[347] As a UK-based owner, the company was first formed by a Spanish design and construction firm and an Australian financial company (50% shares each).[348] Also, Macquarie owns stakes in Brussels' airport and Ferrovial has stakes in Heathrow airport. Some of the airlines serving Glasgow are Aer Lingues, Air Canada Rouge, American Airlines, Blue Air, British Airways, Delta, Emirates, Icelandair, KLM, Lufthansa, Ryanair, Thomas Cook Airlines, TUl, United, and Virgin Atlantic.[349] Glasgow's airlines connect globally to the United States, Canada, the Caribbean, the Middle East, Far East, Europe, and Australia.[350]

Beginning in 2006, the Glasgow Airport Limited invested over £60 million to improve the airport, such as improving the terminal extension, public transportation, security, customer experience, and light enhancements to airfield and taxiways.[351] By 2020, it expects to process 10.04 million passengers, and plans are underway to expand

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[345] Wikipedia, "Glasgow airport."

[346] Wikipedia.

[347] AGS stands for Aberdeen, Glasgow, and Southampton Airports.

[348] Wikipedia, s.v. "AGS airports," accessed November 22, 2017, https://en.wikipedia.org/wiki/AGS_Airports.

[349] For a full listing of airlines, see "Flight Guide, Winter 17/18 & Summer 18," Glasgow Airport, accessed November 23, 2017, https://www.glasgowairport.com/destination-inspiration/route-map/.

[350] "Destination Inspiration," Glasgow Airport, accessed November 23, 2017, https://www.glasgowairport.com/destination-inspiration/.

[351] "Master Plan, Our Vision, Glasgow Airport Draft Master Plan 2011," Glasgow Airport, accessed November 22, 2017, https://www.glasgowairport.com/corporate/about-us/. The master plan is available under the Planning and Development Section of the website; "10 Strategic Airport Enhancements," National Planning Framework 3 Action Programme, accessed November 28, 2017, https://npfactionprogramme.com/national-developments/10-strategic-airport-enhancements/.

the airport infrastructure.[352] The Scottish Executive has considered rail transportation to the airport; and new plans are in place to create a tram-train link to the airport from Glasgow city by 2025.[353] Glasgow airport is not only an important critical infrastructure asset, but it is also a bustling business.

Historically, Scotland has witnessed very few terrorism attacks in comparison to the rest of the United Kingdom. Only two major events have occurred since the 1990s, the 1988 crash of Pan Am Flight 103 over Lockerbie and the 2007 Glasgow airport VBIED attack. The Pan Am Flight was in route from Frankfurt to New York when an IED concealed inside a suitcase exploded in the aircraft that caused its destruction and disintegration over the town of Lockerbie.[354] Although terrorism had been widespread in the United Kingdom during the same timeframe, Scotland had been spared from its effects.[355] The 2007 Glasgow airport attack changed the threat picture.[356] As check-in security screening measures have been hardened since Lockerbie, terrorists are seeking to impact aviation by attacking soft targets, which indeed was one of the reasons the terrorists sought to attack Glasgow airport. The details of their operation are examined in the following section.

2. Synopsis of Attack Event

The two terrorists involved in the 2007 GLA attack, Bilal Abdulla and Kafeel Ahmeed, had attempted two previous unsuccessful VBIED attacks in London before traveling back to their base in Scotland.[357] The previous two attempted and failed VBIED attacks in London revealed gas canisters, regulators, and nails in the vehicles intended to

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[352] Glasgow Airport, "Master Plan," 4.

[353] Catharine Paddock, "Glasgow Airport Train-train Link to Boost Local Economy," *Market Business News*, November 27, 2016, http://marketbusinessnews.com/glasgow-airport-tram-train-link-boost-local-economy/148877.

[354] Wikipedia, s.v. "Pan Am flight 103," last updated January 31, 2008, https://en.wikipedia.org/wiki/Pan_Am_Flight_103.

[355] Gillies Crichton, "Learning from History: The Glasgow Airport Terrorist Attack," *Journal of Business Continuity & Emergency Planning* 8, no. 2 (2014): 169.

[356] Steven Brocklehurst, "The Day Terror Came to Glasgow Airport," BBC News, June 30, 2017, http://www.bbc.com/news/uk-scotland-40416026.

[357] "Behind the London-Glasgow Plot," BBC News, slides 3–4, December 16, 2008, http://news.bbc.co.uk/2/hi/uk_news/7772925.stm,

cause collateral damage on soft targets exiting nightclubs. One Mercedes VBIED was left outside the Tiger Tiger nightclub, and the second Mercedes vehicle was left nearby at Cockspur Street. This second Mercedes was intended to cause a second explosion to kill those attempting to escape the first one. The terrorists had escaped the scene and called the cellphones 15 times in an attempt to initiate the explosion; the cellphones failed to initiate the bombs.[358] The vehicles were discovered by emergency services, and by June 30, the police were closing in on the suspects.[359]

The police had discovered that the terrorists were in Scotland, but did not know what type of vehicle they were driving. Gillies Crichton, who is Head of Assurance at Glasgow Airport, was present on the day of the event and attests to the fact that despite the failed attacks in London, "the Airport Police Commander took the unusual step (despite no intelligence) of putting police officers on the forecourt at Glasgow Airport to ensure that no vehicles were left unattended."[360] This response demonstrates a proactive approach to STS.

The attack on GLA occurred on the second busiest day of the year. School had finished the day before and families had begun their holiday travel.[361] Although it is unknown how much planning went into this attack, court transcripts reveal that the terrorists wanted to copy the 7/7 London attacks. Bilal Addullah testified in court "he had considered attacking Downing Street, Parliament, and Buckingham Palace, but there was too much security."[362] Unknown to the attackers, heightened security was implemented at GLA on the morning of the attack due to police leads and car bombs found in London

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[358] BBC News, slide 9.

[359] Gillies Crichton, "An Examination of the Glasgow Airport Terrorist Attack on 30 June 2007: Embracing Isomorphic Learning to Manage Risk" (master's thesis, University of Leicester, 2013), 3.

[360] Crichton, "Learning from History: The Glasgow Airport Terrorist Attack," 175.

[361] Gillies Crichton, "Glasgow Airport Terrorist Incident," *Blueprint, Enhancing the Profession*, no. 50 (Autumn 2007): 29.

[362] "'Taste' of Fear Sought for Britain," UPI, November 13, 2008, https://www.upi.com/Top_News/2008/11/13/Taste-of-fear-sought-for-Britain/48731226604016/.

the previous night.[363] Unfortunately, this heightened security did not prevent the attack from occurring.

On June 30, 2007 at 15:11, the two terrorists used a VBIED loaded with fuel, gas canisters, petrol bombs, and knives and attacked the main doors of terminal T1.[364] The terrorists attempted to drive a 4X4 Jeep Cherokee into the building's check-in area with the intention of causing a suicide explosion.[365] Terminal T1 houses the majority of travelers checking-in and is densely populated. According to Crichton, "a simple pair of bollards sited adjacent to the doors, stopped the vehicle from gaining access into the crowded check-in hall."[366] Since the vehicle became lodged in a metal pole, one of the suicide bombers aborted the original plot and poured the liquid petrol over himself and lit the inside of the vehicle on fire. While on fire, one of the attackers got out of the vehicle and attempted to open the trunk in an effort to spread the fire onto the gas cylinders to set off the IED.[367] An off-duty police officer used a fire extinguisher to put out the fire on one of the terrorists, while passengers and individual bystanders also took action to bring down the attackers, one of whom suffered a broken leg from kicking the terrorist. The gas canisters remained intact and did not explode (see Figure 16). If they had exploded, the situation could have been much worse.

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[363] Rod Cowan, "Planes, Brains & Auto Mobiles," *Glasgow Airport, Security Insider* 15, no. 1 (FEB/MAR 2010): 20.

[364] BBC News, "Behind the London-Glasgow Plot," slide 11.

[365] Gillies Crichton, "Case Study: The Glasgow Airport Attack from a Business Continuity and Crisis Management Point of View," *Business Continuity Journal* 2, no. 3 (May 20, 2008): 19.

[366] Crichton, "An Examination of the Glasgow Airport Terrorist Attack on 30 June 2007," 3.

[367] BBC News, "Behind the London-Glasgow Plot," slide 15.

Figure 16. Glasgow Airport Attack on Main Terminal.[368]

The vehicle fire triggered the building's fire alarm, which caused passengers to evacuate. Initially, people did not know it was a terror attack but believed it was a car accident.[369] As the smoke moved through the building, it triggered additional alarms and initiated two sprinkler heads in the terminal ground floor.[370] As a result, the entire airport was evacuated and then closed. Firefighters working jointly from the units of Strathclyde Fire & Rescue Service and Airport Rescue & Firefighting were able to extinguish the fire successfully within 30 minutes. Additionally, the Crisis Management Team (CMT) and the Business Recovery Team were called in from home and took immediate action and tactical command to begin to restore business relations. Remarkably, the airport reopened for business on Sunday, July 1, 2007 (23 hours and 59 minutes after the incident).[371]

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[368] Adapted from BBC News, "Behind the London-Glasgow Plot," slide 17.

[369] Crichton, "Learning from History, 175.

[370] Crichton, "Glasgow Airport Terrorist Incident," 29.

[371] Crichton, 29.

3. Attack Impact on Security

The impact to the infrastructure and airport operations was immense. Although the incident occurred outside the terminal building, it caused significant damage to the building's exterior due to the vehicle ramming and fire. Also, significant damage occurred to the interior due to smoke and flooding from the sprinkler systems.[372] The terror attack resulted in 1,100 passengers being held onboard aircraft and approximately 4,500 passengers were evacuated and sent to the Scottish Exhibition and Conference Center for interviewing in the aftermath.[373] All flights were suspended and five individuals were taken to the hospital.[374]

Ten years after the event, the *Daily Record* conducted an interview with the lead investigator of the terror attack, former Detective Superintendent David Swindle. Swindle describes how the investigators were closing in on the terrorists. He believes the airport attack was "spontaneous" because "they failed in London and there was determination to do something."[375] He believes that the terrorists chose an easy target and "if it hadn't been for a concrete stanchion, the Jeep would have entered the terminal building… [and] there would have been fatalities."[376] In fact, the stanchions were made of metal and not concrete.[377] In the article, explosives expert Dr. Clifford Jones explains that if the canisters exploded, *flash-over* from the dispersed gas would have engulfed the entire terminal building and all the lives within it in mere seconds.

Crichton emphasizes that Glasgow has a robust incident command system, including prior to the attack. Due to attacks from the Provisional IRA and a number of major disasters in the 1980s and 1990s, the UK government instituted the Civil

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372 Gillies Crichton, personal communication, Skype Call, December 21, 2017.

373 Crichton, "Glasgow Airport Terrorist Incident," 29.

374 "Glasgow Airport Terror Attack," Airflights.To, accessed February 3, 2018, http://www.airflights.to/Airports/UK/Glasgow-Airport.php5; Wikipedia, s.v. "2007 Glasgow airport attack," last updated January 29, 2018, https://en.wikipedia.org/wiki/2007_Glasgow_Airport_attack#cite_note-MSNBC-1.

375 Paul O'Hare, "The Day Terror Came to Scotland—The Glasgow Airport Attack 10 Years On," Daily Record, June 27, 2017, http://www.dailyrecord.co.uk/news/scottish-news/day-terror-came-scotland-glasgow-10693742.

376 O'Hare.

377 Gillies Crichton, personal communication, Skype Call, December 21, 2017.

Contingencies Act of 2004. This act introduced the integrated emergency management (IEM) model that established a "single framework for civil protection in the UK" and focuses on preparation, planning, response, and recovery.[378] According to Crichton, this framework provided the risk-management process and inter-operability of the responding agencies and assisted in the positive, consistent, and effective recovery of the event. Furthermore, it "puts a statutory requirement… to ensure business continuity is given equal credence before, during, and after incidents."[379] The UK airports stress a multi-agency approach between the airport, airlines, police and government, which was a positive attribute to the success of the event's outcome.

The metal stanchions that prevented the vehicle from attack were not originally designed as bollards to prevent VBIEDs. However, following the 2007 attacks, Glasgow airport banned all vehicles from entering the terminal entrance forecourt and initiated a major renovation project to the terminal building and infrastructure, including adding bollards.[380] The airport invested nearly £25 million between 2010 and 2011 to improve the main terminal building, roads, runway, lighting system, taxiways, and internal layout.[381] It also spent £31 million on the Skyhub project, which improved the internal terminal building and security screening checkpoints.[382] Glasgow airport's design concept of adding bollards was replicated in airports across the globe. The details of Glasgow airport's layout and configuration are discussed in the following section.

4. Airport Configuration and Design

GLA has two terminals; the main terminal (T1) and the smaller T2 (see Appendix E). The T1 terminal has three levels. The ground level has the main ticketing and check-

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[378] Cabinet Office, *Preparation and Planning for Emergencies: Responsibilities of Responder Agencies and Others* (London: Cabinet Office, 2013), https://www.gov.uk/guidance/preparation-and-planning-for-emergencies-responsibilities-of-responder-agencies-and-others.

[379] Crichton, "Learning from History," 171.

[380] Alastair Dalton, "Glasgow Terror Attack Transformed Flying Forever," The Scotsman, June 30, 2017, https://www.scotsman.com/regions/glasgow-strathclyde/glasgow-terror-attack-transformed-flying-forever-1-4490862.

[381] "Glasgow Airport Plans Expansion," BBC News, last updated December 28, 2009, http://news.bbc.co.uk/2/hi/uk_news/scotland/8431770.stm.

[382] BBC News.

in counters (1–39) and access to T2's check-in desks (40–64) for low-cost carriers.[383] This level also provides other services, such as banking, baggage inquiry offices, traveler information, special assistance, and many other customer services. Café and restaurant bars are located near the international arrivals on the west side of the building. This side is intended for public use and for those awaiting passengers to arrive.[384] The main terminal building (T1) encompasses the majority of crowds waiting to check-in.

The first level provides shopping, duty-free, restaurants, and passenger security screening (see Appendix E and note that the first level is in reality the second floor). The majority of the retail stores were moved to the airside area after the 2007 attacks and renovations.[385] This approach is a smart concept because it decreases the number of people in the public non-secure landside. The airport has three piers that are accessible to the passengers after passing through security screening. The east pier houses gates 1–12 for low-cost carriers; the central pier, gates 14–26 for domestic flights; and the west pier, gates 27–36 for international flights (see Appendix D).[386] The second level has offices and an executive lounge.

After the attacks, passenger pick-up and drop-off zones were moved across the main terminal building to a dedicated area adjacent to the "'carparks." Thus, vehicles cannot approach close to the terminal structure. Passengers can also access carpark 2 via the link bridge located on the first level. The carparks are monitored by CCTV and security patrols.[387] Passengers cannot be dropped-off or picked up by private vehicles in

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[383] "Glasgow (GLA) Airport Terminal Map," iFly, accessed November 23, 2017, http://www.ifly.com/glasgow-airport/terminal-map; "Info, Airport Maps," Glasgow Airport, accessed November 21, 2017, https://www.glasgowairport.com/im-picking-up-dropping-off/info/. See the diagram in Appendix E.

[384] "Info, Meeting Someone?" Glasgow Airport, accessed November 21, 2017, https://www.glasgowairport.com/im-picking-up-dropping-off/info/.

[385] "Glasgow Airport Skyhub Project, Scotland," Airport Technology, accessed November 23, 2017, http://www.airport-technology.com/projects/skyhub/.

[386] Glasgow Airport, "Info, Airport Maps"; iFly, "Glasgow (GLA) Airport Terminal Map."

[387] "Parking at Glasgow Airport," Glasgow Airport, accessed November 23, 2017, https://www.glasgowairport.com/im-departing/parking/.

front of the terminals, as they are blocked off.[388] Additionally, vehicle road approaches to the airport have been recently reconstructed by providing for a greater distance between the vehicles and the airport terminal building.

In 2008, BAA completed the Skyhub terminal extension and upgraded the first level by adding an additional 4,000 square meters and integrated several security checkpoints into one.[389] The security checkpoint has an elongated queue. The goal of the project was to reduce passenger security wait times, add more retail stores, and improve the airport's security infrastructure. As the project was completed after the terrorist attack, it provided £1.4 million for new security bollards in front of the terminal. Skyhub was designed by 3DReid and built by Balfour Beatty (see Figure 17).[390] Covered walkways to the carpark and T2 were also added.

The new features to the building include blast resistant materials by Structura.[391] The material is Kalwall, a highly dense composite made to look like glass but can withstand and "dissipate the force of a blast in the event of an incident inside the building."[392] Kalwall has excellent fire retardant proprieties and effectively handles the natural elements. The panels can also be seen in Figure 13 on the exterior of the terminal building, as well as the first level screening checkpoint. This durable material provides safety for the public while simultaneously creating an ambiance of light and tranquility. In the case of an airport environment where crowds form, this type of material would provide a component of CPTED. Additionally, GLA also implements boarding pass

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388 "Pick-up and Drop-off," Glasgow Airport, accessed November 23, 2017, https://www.glasgowairport.com/im-picking-up-dropping-off/pick-up-and-drop-off/; "Glasgow Airport's New Road Layout," YouTube video, 1:12, posted by Glasgow Airport, March 15, 2017, https://www.youtube.com/watch?v=SyNkOlK8JDo; Dalton, "Glasgow Terror Attack Transformed Flying Forever."

389 Airport Technology, "Glasgow Airport Skyhub Project, Scotland"; "Projects/ SkyHub, Glasgow Airport," 3D REID, 2015, https://www.3dreid.com/projects/skyhub-glasgow-airport/.

390 3D REID.

391 "Blast Resistant-Transport," Structura Curtainwall Engineering, 2012, http://www.structura-uk.com/kalwall/KAL_Blast_Trans_GLA.php.

392 "Research and Development Plant," Structura Curtainwall Engineering, 2012, http://www.structura-uk.com/kalwall/KAL_Explo_Ind_JAN.php; "About Kalwall," Structura Curtainwall Engineering, 2012, http://www.structura-uk.com/kalwall/KAL_About_Kalwall.php.

turnstiles before passengers enter the security-screening queue.[393] These turnstiles add an additional layer of security for soft targets.

1. Exterior Terminal Bollards

2. First Level Skyhub Screening Checkpoint

Figure 17. Skyhub Project, Bollards and Screening Checkpoint.[394]

5. Case Analysis: Glasgow

Learning from events is the best way to implement measures to mitigate future attacks. Crichton describes three types of learning that can take place from events in which organizations can mitigate risk: *foresight* and *hindsight learning*, *active learning*, and *isomorphic learning*. Crichton posits that GLA realized isomorphic learning from the London terrorist events of 7/7 "to ensure that the hindsight learning was converted into active foresight."[395] He describes how Lord West, the Home Office Parliamentary Under-Secretary of State at the time, implemented counter-terrorism strategies in the United Kingdom to protect crowded places from these types of attacks. These counter-terrorism strategies gave additional scrutiny to places of mass gatherings, particularly from VBIEDs.[396] Consequently, modifications were made to external roadways via

[393] Gillies Crichton (Head of Assurance, Glasgow Airport), in discussion with the author, November 28, 2017.

[394] Adapted from 3D REID, "Projects/ SkyHub, Glasgow Airport."

[395] Crichton, "An Examination of the Glasgow Airport Terrorist Attack on 30 June 2007," 19–20.

[396] Crichton, 19–20.

barriers and an ANPR system to permit only known vehicles to enter the forecourt area.[397] Crichton attests to the fact that "Glasgow Airport in hindsight spent in excess of £1.4 million in alterations to the road layout to protect the terminal frontage following consultation with the Centre for the Protection of National Infrastructure."[398] Through lessons learned, these environmental design elements were integrated into the physical security of the airport after the attack.

An amazing attribute in the case of GLA is that it was one of the first five airports to pilot MATRA prior to its national implementation in 2003.[399] According to Crichton, it was based on another identified isomorphic learning event from 7/7 because, "the 7/7 inquest identified a need for improved interoperability between all of the responding agencies."[400] By learning from the events of 7/7 and understanding that better inter-agency cooperation and training is essential, the response to the terrorist event of 2007 was highly successful.

What would have been the result if these implementations had not taken place: the environmental design, the training, and the inter-agency relationship strengthening? Crichton credits the MATRA process and projects Argus and Griffin as establishing these links in training, exercising, and liaising, and he confirms that joint drills existed at the national and regional level prior to the attack.[401] Crichton credits "the seven R's" as the effective GLA crisis management and business continuity system: risk, resilience, response, recover, rehearse, review, and repetition.[402] These seven R's were the pillars to a well-established preparedness and response plan at the airport level. In fact, Crichton's dissertation found that GLA is indeed risk aware and effectively manages risk.

How did GLA's environmental design contribute to terrorist target selection and attack methodology? According to Cowan, "although the media reports claimed that

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397 Gillies Crichton, personal communication, Skype Call, December 21, 2017.

398 Crichton, "An Examination of the Glasgow Airport Terrorist Attack on 30 June 2007," 20.

399 Refer to thesis Chapter II for the discussion of MATRA.

400 Crichton, "An Examination of the Glasgow Airport Terrorist Attack on 30 June 2007," 22.

401 Crichton, 23.

402 Crichton, "Learning from History," 172.

security bollards had stopped the vehicle, the only thing in place at the time was chrome tubing at ground level around the entrance, designed to stop luggage trolleys from damaging the wall."[403] Cowan claims that it was the terrorists' poor driving skills that led to their failed attack and not the "chrome tubing" *per se*. This view provides the possibility that the terrorists perceived that they were indefensible; hence, they attempted to drive the vehicle through the poles.

The poles were thin and pictures of them reveal that they were spread apart from each other, which might have given the terrorists the perception that they could drive between them (notice the red arrow pointing to the second metal pole in Figure 16). The picture by the *Daily Record* shows a wide distance between this pole and the one that was struck (see red line in Figure 18).[404] If the poles had not held up, the Jeep might have entered the crowded terminal building space. Since over 3,000 people were in the building at the time of the attack, the explosion and flashover from the gas tanks might have caused a disaster.

Figure 18. Entrance to Terminal 1.[405]

[403] Cowan, "Planes, Brains & Auto Mobiles," 22.

[404] O'Hare, "The Day Terror Came."

[405] Adapted from O'Hare.

The GLA incident caused governments worldwide to assess the protection of airports' critical infrastructure. For example, Israel's homeland security "recommended the installation of robust physical barriers as protection against vehicle bomb attacks and the creation of vehicle exclusion zones to keep all but authorized vehicles at a safe distance."[406] Since the event, GLA has installed 300 steel barriers around the terminal that cost $3.6 million.[407] As can be seen from post-event pictures, the new bollards have been designed and built to the Publicly Available Specification (PAS 68) standards, placed farther from the terminal building, and are reinforced by their larger size and closer proximity to each other (see Figure 19).[408]

Figure 19. Glasgow Airport Post Attack.[409]

[406] "Vehicle Ramming Attacks: Are There Any Security Measures?," iHLS, January 9, 2017, https://i-hls.com/archives/74006, paragraph 10; "NHS Doctor Jailed for 32 Years for Bungled Terror Bomb Plot," *Daily Mail*, http://www.dailymail.co.uk/news/article-1096822/NHS-doctor-jailed-32-years-bungled-terror-bomb-plot.html.

[407] Kevin Kostiner, "Glasgow Airport's Security Improved after Terror Attack," Copybook, November 9, 2009, https://www.copybook.com/news/glasgow-airports-security-improved-after-terror-attack; Cowan, "Planes, Brains & Auto Mobiles," 22.

[408] "What is PAS 68?" HEALD, accessed January 11, 2018, https://www.heald.uk.com/what-is-pas-68/.

[409] Adapted from "Experiential Space @ Glasgow Airport," WeArePopUp, accessed December 9, 2017https://wearepopup.com/u/brand-promotion-site-gl/.

Environmental design counter-measures in the United Kingdom, however, are not novel features. The ACI's magazine *Airport World* declares, "the UK is possibly a world leader in this area due mainly to the former threat of the Irish Republican Army (IRA), which between 1970 and 2001 used weapons such as car bombs and other explosive devices in a long running terror campaign against the British Government."[410] Due to these threats, the UK's DfT instituted the aviation security in airport development (ASIAD), which established guidance to airport designers and operators for passenger security screening and airport terminal building design measures.[411] According to *Airport World*, it includes forecourt terminal security and VBIED design counter-measures. For example, it requires a 30-metre vehicle free zone around the landside terminal, which is "delineated by structures such as bollards, planters or other landscaping features to stop unauthorized entry into the area, or attack, by vehicles at speed."[412] Additional guidance from the document includes entry and egress zones, movable barriers, car park locations, terminal glazed facades and structures, aircraft hold luggage, and delivery routes.

The ASIAD also considers blast loading and impact. In the United Kingdom for example, "a design stand-off of 30 meters is applied for car bomb devices [because] frame buildings designed to British Standards and UK Building Regulations are generally capable of withstanding the blast without collapsing" at this range.[413] This feature is intended to maximize standoff between the target and the explosive. Furthermore, structure fragments and debris from explosion shock waves are configured into the terminal design infrastructure. *Airport World* asserts that "glazing blast assessment tools and computer models have been developed, as well as blast-enhanced glazing systems" that minimize blast fragmentation by attaching to a plastic interlayer.[414] This development is accomplished by using bonded silicone in the interlayer to absorb the blast wave. The GLA Kalwall window system is an attestation of this type of technique.

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[410] "Asset Protection," Airport World, November 15, 2009, http://www.airport-world.com/features/safety-security/723-asset-protection.html.

[411] Airport World, paragraph 6.

[412] Airport World, paragraph 7.

[413] Airport World, paragraph 13.

[414] Airport World, paragraph 14.

The same system can be designed in doors. The end result is an attractive and safe building material for STS.

Airport World affirms that airports also need to consider interior design, such as terminal façade and building structure, to prevent "package or person-borne device" and to mitigate injuries from attack. The ASAID considers the following features:

- Limiting the extent of glazed balustrades and screens and designing those remaining with laminated glass to limit the creation of hazardous fragments
- Providing securing restraints to large suspended signs and high level suspended ceiling panels to prevent them becoming detached and falling onto people
- Avoiding glazed screens at check-in desks
- Requiring retail units and ticket and information booths to comply with blast mitigation design criteria
- Shielding off high-density public areas, such as check-in zones, from each other to limit the extent of blast effects[415]

Airport operators and engineers understand that a balance exists between risk mitigation and adequate human use of space, without being restrictive. *Airport World* also agrees that design measures "should be seen as part of a larger counter-terrorist strategy that includes the work of the airport operators, police, security services and other agencies."[416] The crucial element to consider is how these factors work together to enhance the physical environment for threat mitigation, and assist law enforcement and emergency personnel in effective response.

[415] Airport World, paragraph 20.

[416] Airport World, paragraph 26.

6. Implications of Airport Design

The GLA case provides lessons for foresight in environmental design preventive counter-measures. Based on the airport configuration, GLA's public terminal landside space is business oriented and provides ample opportunity for crowds to form. Hence, protective counter-measures must be considered to protect the soft targets. The terrorist attack of 2007 demonstrated how simple environmental elements, although not originally designed for this purpose, prevented a calamity from occurring.

The environmental design elements further helped the first responders contain the vehicle in one location. The vehicle became lodged on the pole; hence, the terrorists were trapped and could not continue to move forward or backward. The trained police and emergency response personnel added the additional layer of protection and speedy recovery that demonstrates a great example of how multiple layers (people and environment) can work together to contain the threat.

The GLA case shows the United Kingdom's ability to integrate crowd protection through environmental design and policy. They have taken it a few steps further by rebuilding, redesigning, directing people and vehicle flow, and establishing a comprehensive approach to STS. By considering blast protection and building structure elements to limit debris and destruction, the ASAID provides a great resource in multiplying its effects in airports throughout the world.

GLA's burgeoning business has proven contrary to the belief that implementing physical security will detract customers. Indeed, by upgrading environmental security and protecting the traveling public, GLA has continued to see increasing passenger flows. GLA has implemented smart security that is people-centric, properly trained, with an experienced emergency management team. The key is that the driving policy considers crowd protection *first*, and by protecting the people, the airport's main assets, business, aviation industry, and economy can thrive. These are lessons that airports and homeland security professionals can realize and implement across the globe.

IV. AIRPORT DESIGN

As illustrated by the cases in Chapter III, airport design, layout, infrastructure, and security can have an enormous positive impact on protecting the soft target. Each airport built around the world is unique and no ubiquitous method is available that secures soft targets. Yet, security measures can be overlaid or incorporated into the existing environment. While retrofitting is costly, if applied strategically, it can be cost-efficient when it minimizes casualties and prevents attacks from adversaries. Gersema's research shows that an "airport checkpoint attack would result in a $17 billion decrease in GDP due to lost air travel," and an estimated $13 billion of GDP loss would result if the attack occurred on an airline.[417] Additionally, "airlines would suffer the bulk of the losses in both cases—about $1.5 billion in gross revenue in the first year after the attack and $690 million in gross revenue the second year."[418] Mitigating attacks on soft targets provides airport infrastructure developers with effective methods to counter terrorism in airport buildings and saves the aviation industry from economic burden.

As shown previously, crowds form in certain areas of the airport, so design measures should focus on these areas, specifically. In the airport public-side terminal, crowds typically form in the airline check-in ticket counters, passenger screening checkpoint queues, and baggage claim areas. This chapter stipulates design recommendations to mitigate attacks on crowds in these precise locations. Recommendations are provided for blast mitigation, physical structures for gunfire mitigation, and considerations for altering visual cue perception of soft targets (i.e., creating an optical illusion effect to change target risk perception). CPTED principles are considered in each stage of the design recommendations.

The key point to consider is that a *systematic method* to STS must be applied. Physical structures and simulation models must also be considered to achieve this goal.

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[417] Emily Gersema, "Attack on an Airline or Airport Could Cost the Economy Billions in Losses," USC News, February 9, 2017, paragraphs 8, 9, https://news.usc.edu/116174/attack-on-an-airline-or-airport-could-cost-the-economy-billions-in-losses/.

[418] Gersema, "paragraph 10.

This chapter offers conceptual models of crowd formation and movement. To protect crowds, it is crucial to consider their stagnation and movement in the airport environment. Risk modeling and attacker-defender models are also useful to consider in establishing a systematic approach for crowd protection.

A. CHOOSING WHAT TO PROTECT

It is first necessary to begin with what needs to be protected. As discussed in Chapter I, countermeasures are now in place to prevent the prohibited items of guns and explosives from entering aircraft, and multiple security layers are applied to prevent an aircraft hijacking. Aviation security measures continue to focus on past threats, such as those that brought down the planes on 9/11. Jackson et al. assert that "security strategies to protect the aviation system…have also been criticized as being reactive and backward looking, seeming to always be responding to the last observed threat."[419] In the case of an airport, adversaries consider the opportunistic attack towards masses. Recent attacks, as presented in the case studies of Brussels, Glasgow, and Los Angeles show an adversary shift to soft targets. If the goal is to mitigate threats in the aviation transportation system, soft targets in airports are currently the most visible and vulnerable components of the aviation sector.

Airport owners need innovative techniques to decrease the prospect of an opportunistic attack. One mode is to apply the CPTED principles in the aviation environment, particularly in areas where crowds form. Three areas stand out in the public space of the airport: *airline ticketing queues, screening checkpoint queues*, and *baggage claim areas*. If the principles are applied in these limited areas, the probability of attack or the consequences of such attacks can decrease significantly. By applying the right amount of environmental counter-measures, life loss can be mitigated. Additionally, constructing the built environment to limit debris from explosive shockwave and gunfire enhances crowd protection.

[419] Jackson et al., *Efficient Aviation Security*, 3.

1. Airline Ticketing Queues

In airports across the globe, passengers form lines to check-in or purchase their tickets. Although the popularity of electronic ticketing is growing, lines still form in these spaces because passengers need to check-in baggage (or other items), some individuals prefer not to use electronic tickets, or some may not have the technology to purchase tickets online. Hence, airlines and airports must always be prepared to expect passengers and crowds in ticketing areas. Furthermore, crowds in these areas form before a flight, and if several flights depart simultaneously, then crowds will be larger.

Airline ticketing queues in most large U.S. airports have a general layout. The layout consists of check-in ticket counters where airline employees assist passengers with checking in luggage, a conveyer belt (or some other system to move luggage to the aircraft), and possibly electronic kiosks to purchase or print tickets. On international flights, these ticket counters become even more crowded because of the number of passengers checking in luggage.

Crowds form up to two hours before a flight because airlines have check-in time requirements a minimum of 45 minutes before a flight. The timeframe may also vary for each airline. In large airports, approximately 300–400 people wait in line for 20 minutes to check-in.[420] These peak passenger loads occur simultaneously throughout the airport terminals; consequently, maximizing probable target locations or opportunities for multiple attacks. Currently, no physical security process has been put in place to protect individuals confined in this area from attack. The Brussels case study provided a descriptive analysis of the vulnerability of passengers in these areas. The case proved the ease of a terrorist attack. The Glasgow airport attack is also a reminder that the terrorists sought to kill masses of people in the ticketing area by attempting to drive a VBIED into the building. Recommended countermeasures to protect this area are provided in the following section.

[420] Stevens et al., *Near-Term Options for Improving Security at Los Angeles International Airport*, 22.

2. Screening Checkpoint Queues

Passengers must transit through a TSA security checkpoint after ticketing and baggage check-in. The checkpoint queues result in longer lines because everyone who moves to the sterile side of the airport, even those not flying, must process through screening. The TSA screens everyone, including airline workers, flight crew, airport employees, vendors, contractors, law enforcement officers requiring specialized screening, and any accompanying passenger escorts. The crowds increase in the screening queues because it takes more time to perform the physical screening of passengers and carry-on luggage than to administer a ticket. Furthermore, only one checkpoint servicing several departing flights for multiple airlines may be available (see example Figure 20 at JFK International airport), which thus creates one grand queue. Again, there are no physical security measures to protect the individuals confined in the screening queue.

Figure 20. John F. Kennedy Airport, Terminal 1 Lobby Entering Screening Queue.[421]

The screening passenger queue is most often designed in a "S" pattern with 90 or 180 degree turns to control flow (see Figure 21). According to the *Recommended Security*

[421] Source: "JFK, Terminal 1, Inside, Departure Gates," Mapio.net, accessed February 17, 2018, http://mapio.net/pic/p-47637672/.

Guidelines for Airport Planning, Design, and Construction, "queue lanes are approximately 3–5 feet wide" and the TSA recommends a minimum of nine square feet per passenger.[422] The pattern type creates a large number of individuals per square foot. However, this type of design causes several issues: 1) passengers cannot easily disperse or escape when in danger, 2) a large number of people are located in a confined space, 3) the crowd becomes an easy target for adversaries, and 4) this design provides the perception of opportunistic attacks for adversaries. Furthermore, the queuing area leads to expensive screening equipment that can cause collateral damage and shrapnel in the case of an explosion. Mass casualties in this location would certainly debilitate air travel. The Los Angeles case demonstrated how defenselessness passengers could be in these areas.

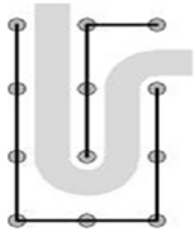

Figure 21. Typical Queue Pattern.[423]

3. Baggage Claim Areas

Baggage claim areas produce crowds of passengers in an unsecured portion of terminal. The Fort Lauderdale shooting of 2017 demonstrated the vulnerability of this type of attack.[424] In most airports across the globe, baggage from several flights will migrate to one baggage claim area (see Figure 22). Several baggage carousels may be located within the baggage claim area where passenger crowds form. It takes some time for the bags to reach the carousel and passengers crowded in this area may wait there for

[422] National Safe Skies Alliance, Inc., "Recommended Security Guidelines for Airport Planning, Design, and Construction," 118.

[423] Adapted from "Better Layouts for Queue Lines," Jim Watson, http://www.jamesrobertwatson.com/quelines.html. Reprinted with permission.

[424] Emily Shapiro, Julia Jacobo and David Caplan, "Veteran Allegedly Kills 5 at Fort Lauderdale Airport Shooting, Terrorism Not Ruled Out," ABC News, January 7, 2017, http://abcnews.go.com/US/shooter-custody-incident-fort-lauderdale-airport-injuries-reported/story?id=44602546.

upwards of 20 minutes. This area is public space and family members greeting the passengers may also be gathered there, which additionally increases the number of individuals and crowds that can form. Passengers on international flights usually carry more luggage than domestic travelers, thereby increasing the wait time further. Presently, no physical security measures can deter an attack in this space.

Figure 22. Baggage Claim at Fort Lauderdale Airport, Terminal 1.[425]

B. KNOWING HOW TO PROTECT

Knowing that these three public areas are the most vulnerable to attack can narrow down where the security countermeasures are implemented. The key is to position the countermeasures according to the adversary's success perception. In other words, how successful do adversaries think they will be if they attacked the crowd in these locations? What is the ease of pre-attack surveillance? What is the probability of detection? Where would the attacker enter? How would the adversary move toward the soft target? What type of weapon can inflict the most damage? Can the adversary escape after the attack? What type of collateral damage can be inflicted on people from the

[425] Source: Clemence Michallon et al., "Revealed: FBI RETURNED Ft. Lauderdale Shooter's Gun a Month before Airport Attack after He Reported Himself because He Thought the CIA was Making Him Fight for ISIS," *Daily Mail*, January 7, 2017, http://www.dailymail.co.uk/news/article-4097416/Gunman-picked-passengers-sent-crowds-fleeing-airport.html.

destruction of the built materials (surrounding debris, shock impact, glass, metal, ceiling fixtures, etc.)? These questions must be answered when performing a risk assessment of these locations.

1. Recommendation: Apply CPTED Countermeasures

The aforementioned countermeasures can all be constructed using CPTED principles. Each of the airport terminal areas can incorporate elements of environmental design that enhance defensible space. Much like the TSA layers of security, CPTED also provides security in layers. According to Sakip, Johari and Salleh, "various studies have found that the built environment does influence criminal behavior."[426] The authors surveyed residential areas in gated and non-gated communities. Their study found a significant correlation and positive relationship between CPTED practices and fear of crime that thereby makes communities safer and decreases crime.[427] Fennelly and Crowe also attest that "significant results have been produced in many places, including residential areas, convenience stores, malls and shopping centers, transit stations, and parking structures."[428] For example, convenience stores have reduced losses up to 50% from theft and 65% from robberies.[429] The positive effect is that the *users* of the space also feel safer. The basic premise to CPTED's foundation is based on human activity and human perception of the environment.

CPTED provides for four basic principles for "defensible space": *territoriality, surveillance, maintenance*, and *access control*.[430] Prevatt expands on these principles as follows: *territoriality* is a physical motif that gives users of the space a sense of

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[426] Siti Rasidah Md Sakip, Noraini Johari, and Mohd Najib Mohd Salleh, "The Relationship between Crime Prevention through Environmental Design and Fear of Crime," *Procedia- Social Sciences* 68 (2012): 629, doi: 10.1016/j.sbspro.2012.12.254.

[427] Sakip, Johari, and Salleh, 634.

[428] Lawrence Fennelly and Timothy Crowe, *Crime Prevention through Environmental Design* (Amsterdam: Elsevier Science, 2013), 12, ProQuest Ebook Central, https://ebookcentral.proquest.com/lib/ebook-nps/detail.action?docID=1222590. See Fennelly and Crowe for analysis in crime reduction, 12–14.

[429] Fennelly and Crowe, 12.

[430] Sakip, Johari, and Salleh, "The Relationship between Crime," 629; Juliana S. Prevatt, "Crime Prevention through Environmental Design (CPTED) and the Role of Facilities Planning in Force Protection" (master's thesis, Graduate School of the University of Florida, 1998), 1–339.

ownership and control, *surveillance* is a built-in environmental form to make strangers feel they are being watched, *access control* limits strangers ability to gain entry and increases their perception of risk, *activity placement* is a spacial design that predicts movement behaviors of users and strangers, and *maintenance* shows ownership, caring for, and image of the environment; mainly, to provide strangers the perception to keep out. The sign "beware of dog" is a good description of this concept.

Prevatt argues, "CPTED techniques tend to be less expensive and more sustainable in the long run than the more traditional methods of security which have their emphasis on organized and mechanical security strategies," such as guards or human resources and reinforced door locks.[431] CPTED defensible space options provide for *natural* surveillance and access control, a concept crucial to the understanding and utilization of CPTED. Prevatt emphasizes that CPTED is different from traditional target hardening because natural surveillance can be aesthetically pleasing. She stresses that it "concentrates on using the *natural environment to manipulate behavio*r instead of relying on electrical or mechanical devices, or additional human resources, although these latter methods are not ruled out" (my emphasis).[432] CPTED's principle aim is to define how users perceive the spatial environment to defend against intruders.

Fennelly and Crowe provide a clarification on the concepts and classifications. They demonstrate how access control and surveillance are broken down further into three categories: organized, mechanical, and natural (see Figure 23). Again, they stress that these physical environmental design approaches use the natural ambient to prevent crime. In essence, they argue that this approach creates territoriality and a sense of proprietorship so that offenders can sense it.[433]

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[431] Prevatt, 13.

[432] Prevatt, 3.

[433] Fennelly and Crowe, *Crime Prevention*, 28.

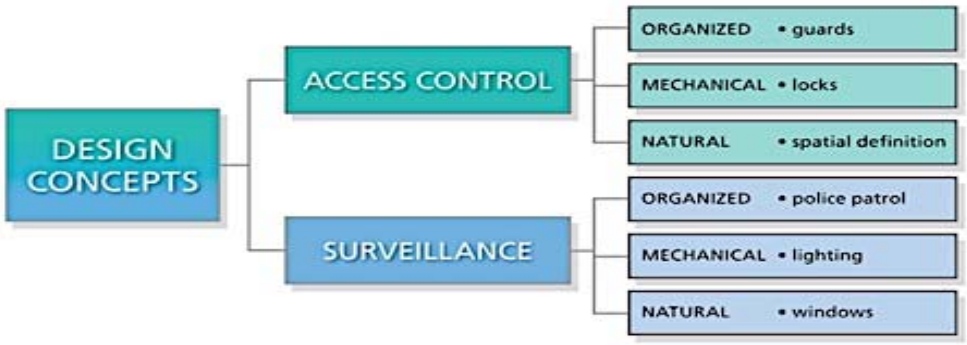

Figure 23. Concepts for Access Control and Surveillance.[434]

The airport environment is an optimal opportunity to use and test these principles. Some of these elements are already inherent, such as maintenance, territoriality, and access control, and incorporating the other elements of CPTED would not be difficult, especially since the airport environment is a controlled space. Prevatt makes a great point when she claims that "the objective of designing for security is to design a space that will facilitate the normal users, discourage the abnormal users, and still be accessible for its intended—designed—use."[435]

Airport owners and operators want their space to be customer friendly, and CPTED's ability to use aesthetics is a win-win for STS. For example, in most areas where CPTED principles are employed, the placements of landscaping and lighting have a significant impact on the defensible space, which is often the case with residential homes. Bushes and shrubs are often planted around the windows to deter someone from breaking in. As can be imaged, it is difficult to break in through a window while standing on a bush. The case is similar with lighting at door entrances in homes, which provides for natural surveillance; the robber would not want to be seen breaking into a home. Fennelly and Crowe attest to the fact, "CPTED involves design of physical space in the context of the physical, social, and psychological needs of bona fide users of the space, the normal and expected (or intended) use of the space (the activity or absence of activity planned for the space), and the predictable behavior of both bona fide users and

[434] Source: Fennelly and Crowe, 28.

[435] Prevatt, "Crime Prevention," 13. Reprinted with permission.

offenders."[436] Hence, the design features recognize the full utilization of the space, which is currently lacking in most airports.

CPTED principles try to diminish the "fortress effect" by minimizing the use of target hardening.[437] Biometrics, CCTV, screening equipment, airline ticketing technology, and baggage systems are a requirement for proper airport and aviation functioning. Technology is an essential component of how airplanes function, and the users (passengers) have a level of expectation to have these in place. For the most part, the missing element in the airport environment is the use of the natural environment, or the *creation* of a natural space that can include indoor planters, water features, art, and even artificial bushes and shrubs used to create a defensible space. Artificial bushes, shrubs, and plants provide an aesthetic appeal, as well as create a camouflage effect (limit visual acuity of distant objects to prevent pre-attack surveillance and obscure the adversary). The camouflage effect can be accomplished with aesthetic netting and mirrors (see example Figure 24). Jackson et al. claim "deterrence is based on adversaries' perception of capabilities, and deterrence can be engendered through deception even when actual capabilities are quite limited."[438] Applying the camouflage effect can achieve this goal. Lightweight materials, such as fabric, can also achieve a camouflage effect.

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[436] Fennelly and Crowe, *Crime Prevention*, 26.

[437] Prevatt, "Crime Prevention," 6; See also Fennelly and Crowe, 24.

[438] Jackson et al., *Efficient Aviation Security*, 70.

Figure 24. Metal Fabricated Façade by A. Zahner.[439]

Prevatt is a reminder that CPTED principles derive from environmental psychology in which "there is a direct relationship between the environment and human behavior."[440] This concept is often underestimated, although, extensive research in environmental psychology has demonstrated its significant effects. This effect is achieved by manipulating the environment such that it instills fear toward those that seek to do harm. Imagine active shooters in an airport having to run over bushes or other barriers to achieve their target. Or image that they cannot fully assess the target because they cannot see the crowd in full view. All these elements would deter a plan of attack, or an attack in motion.

Fennelly and Crowe describe six elements that impinge human behavior in the social environment: *temperature, pressure, humidity, light, sound,* and *gravity* (see Figure 25).[441] They describe the metabolic elements as biological, where the near environment is scanned using people's senses who then determine how to proceed. They argue that security can be achieved by manipulating the environment to affect these human

[439] Source: Tom Stoelker, "Zahner, Zaha's Schumacher, CASE, and More: Facades Conference 2012," *Architect's Newspaper*, February 16, 2012, https://archpaper.com/2012/02/live-blogging-collaboration-facades-conference/.

[440] Prevatt, "Crime Prevention," 14.

[441] Fennelly and Crowe, *Crime Prevention*, 72–73.

reactions. They describe how the use of color and light can impact biological changes, such as increasing and decreasing human energy levels. Fast food restaurants and medical offices, for example, have been using these tactics for years to attract customers and increase sales. Fennelly and Crowe also provide a CPTED assessment form for malls and shopping centers, which can prove useful in an airport terminal as well.

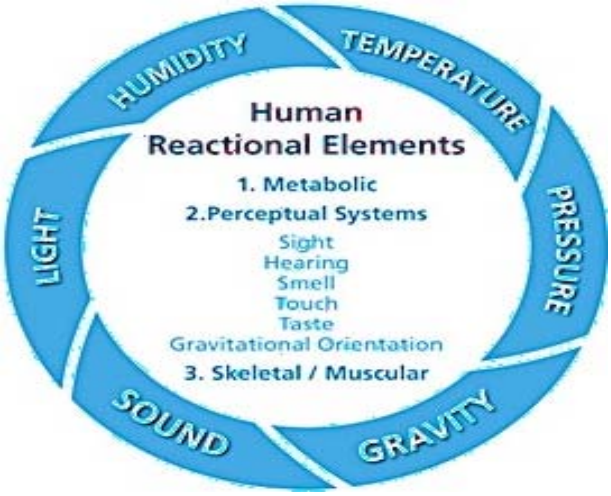

Figure 25. Human/Environment Relationships.[442]

a. Screening Checkpoint Queue

The best CPTED approach to the screening checkpoint queue is to minimize the number of passengers enclosed within the queue, which can be accomplished in several ways. First, instead of an "S" queue model, the queue can have an elongated shape. The goal is to decrease the number of individuals confined per square foot to minimize casualties from an IED attack. Second, the line queue must appear smaller or not entirely visible from a single angle. For example, the queue can curve around the space of the terminal with objects that can block the view of the line; hence, not allowing the adversary to pre-surveil or see the "big picture." The objects can consist of large planters, artwork panels, frosted blast-resistant glass, or moving water features. Adaptable and constantly changing lights also provide effective perceptual cues; and by making it

[442] Adapted from Fennelly and Crowe, 72. Reprinted with permission.

appear non-crowded, alter the perception of the line. For example, having different colors shine down from above on various areas of the queue alters perception (as used in theater production).

People are calmer when the noise volume is decreased. Lowering the volume makes the crowd appear sensually smaller. Adding noise-absorbing materials can further decrease the noise volume. Having passengers weave through large objects also obstructs the view of the line. Another option is to place alternating walls between the queues to block views of the line from a single angle. The large objects can provide shockwave explosive absorption and cover from gunfire. This type of design touches on the human reactional elements (Figure 25) that thereby alters the adversaries' perception of the crowd and deters target selection.

Grant and Stewart conducted a cost-benefit analysis and compared *distributed* passenger screening queues to *centralized* queues to examine the human causality rate from a person-carried IED (see Figure 26).[443] They affirm that "structure and format of existing security layers, and the potential for an IED attack directly upon a security point, check-in counter or baggage reclaim point… may provide significant threat reduction to personnel for little expenditure."[444] The results of their study showed that distributed security systems yielded higher casualty reductions than centralized security systems. The cost-benefit analysis revealed a benefit-to-cost ratio for the distributed systems to be from $440,000 to $132,000 per year.[445] They assert, "distributing security points should be seriously considered as part of any airport terminal design or remodeling."[446] Each airport construct is unique. Although it may not be simple to realize distributed systems queues in these spaces, it is important to consider the benefit they provide to crowd attack mitigation. It is relevant to consider these design elements even if the queue cannot be constructed to a 100% elongated path.

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[443] Grant and Stewart, "Benefit of Distributed Security," 021003–1.

[444] Grant and Stewart, 021003–2.

[445] Grant and Stewart, 021003–7. The benefit-to-cost ratio for the upper cost is set at 0.3 and the lower cost to 1.

[446] Grant and Stewart, 021003–7.

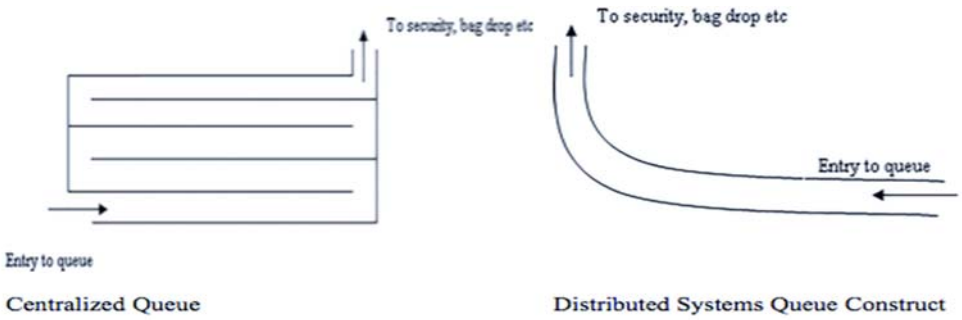

Figure 26. Centralized versus Distributed Systems.[447]

b. Airline Ticketing Area

The airline ticketing area has seen some remarkable improvement in newly renovated airports. The number of individuals congregating in one location to print boarding passes or check-in is decreasing particularly due to the expansion of ticketing kiosks throughout the terminal. The advent of technological check-in applications and electronic tickets is also helping. Passenger technology for pre-paying and weighing check-in luggage (pre-airport arrival) needs to be advanced, and a method to check-in luggage via computer established. Passengers would then need to only drop off their luggage at designated locations throughout the airport. Valet service should also be an option.

Utilizing bomb-sniffing dogs at these designated locations provide an additional layer of deterrence. Police and canine patrols in the airline ticketing area and designated luggage drop-off points would further enhance CPTED security. Adversaries would be less likely to attack if a mitigating figure was in that area; specifically, due to the chances of diminished opportunistic perception of success in their operation.

The physical layout of the kiosks would also need to be considered. For example, if an active shooter aims at the crowd, can the passengers seek cover or easily escape the area? If an IED explosion occurred, how much debris and shrapnel would be created that can hurt individuals? What is the pattern of crowd flow in this area? By applying the crowd decreasing factors described previously (technology, diversified kiosk locations,

[447] Adapted from Grant and Stewart, 021003-4–021003-5. Reprinted with permission from authors.

and multiple luggage drop-off zones), adversaries would not perceive an opportunistic attack. Additionally, the risk of a successful attack increases.

Tactics, such as designated passenger drop-off zones, canine police patrols, behavior detection and random public side screening, are presently used in Brussels and Glasgow. Their designated passenger drop-off and pick up zones are in specified locations outside the terminal building to minimize explosion impact to the airport terminal infrastructure. GLA's designated vehicle zones are thoroughly planned and designed to mitigate attack, and they offer the best methodology to emulate regarding the movement of vehicles, passenger drop-off and pick up zones. The UK's *Protecting Crowded Places: Design and Technical Issues* document provides recommendations for counter-terrorism protective measures (See Appendix G). The measures include blast resistance, building management, traffic and vehicle mitigation factors, building, and better search and screening measures.[448]

c. Baggage Claim

Baggage claim areas provide the most open space in the terminal. With the exception of the baggage carousel, people can often move around and disperse within this area. They are, however, limited in their ability to seek cover in the cases of an active shooter or explosion. Since passengers gather around the carousel, the crowd is inherently more dispersed in comparison to a screening checkpoint or an airline ticket counter.

The countermeasures in this space can be configured in several ways. One method is to place objects (planters, water features, lights, adaptable and frosted barriers) that modify the overall view of the crowd around the carousel to obstruct an attacker's view. Another method is to place the baggage claim in an inaccessible area to the general public. An example would be to place it behind secure doors or turnstiles that require a boarding pass. In Brussels, this strategy is presently used and can be transferred to the airport configurations in the United States. Family greeting areas would need to be relocated, possibly outside the building and beyond the bollard zones. Additional deterrence measures may include more police, canine, or robot patrol. Security signs,

[448] Home Office, *Protecting Crowded Places*, 12.

such as "be aware; security camera surveillance in progress" would provide the CPTED measure of defensible space surveillance. The CCTV cameras should be large and clearly visible by the public. These CPTED elements would again provide the perception of countermeasures as described earlier.

2. Recommendation: Independent Risk Assessment Groups

Risk assessment should be completed at airports nationwide for each location; airline ticketing queues, screening checkpoint queues, and baggage claim areas. Similar to the UK model of the RAG and SEG (refer to Chapter II), an independent group of subject matter experts should assess attack methodology, which can also be developed into a game theory model. For example, RAND conducted a risk assessment in 2004 at LAX in which all vulnerabilities were compared, as well as the cost for mitigation.[449] The study found that crowds in the ticket counter presented the highest vulnerability for attack. It would be useful to have similar assessments conducted on an annual or bi-annual basis across all U.S. category X airports so that they can stay current with the evolving threat.

Each airport's configuration is distinct, so it is critical that airport boards, aviation partners, the TSA, police, airlines, and key stakeholders are incorporated into the risk assessment and design evaluation. Subject matter experts in attack methodology, such as individuals from the police, military, or other special units, should be considered in providing expertise toward the risk assessment. Lundberg and Willis describe a qualitative approach to risk assessment, the *Deliberative Method for Ranking Risks.*[450] The method developed from research in Carnegie Mellon University between 1990 and 2000. It has five steps:

> 1) identifying the risks to be ranked; 2) identifying important attributes to describe the risks; 3) describing each of the selected risks in terms of the

[449] Stevens et al., *Near-Term Options for Improving Security at Los Angeles International Airport*, 22.

[450] Russell Lundberg and Henry Willis, "Assessing Homeland Security Risks: A Comparative Assessment of Ten Hazards," *Homeland Security Affairs* 11, art. 10 (December 2015), https://www.hsaj.org/articles/7707.

selected attributes; 4) selecting participants and performing the risk ranking, and; 5) analyzing results.[451]

This tool provides an effective means to establish risk exposure because it was born from environmental policy and a hazards approach to threats. It is useful because it provides the ability to determine the amount of lives lost per event, such as terrorist attacks.

Airports are small communities, and a systems approach to this process must also be considered. The Dallas Love Field shooting in June 2016 outside a baggage claim area exemplifies this approach. In this case, passengers rushed in the secure area of the terminal for safety after they heard gunfire, which compromised sterile area security. Flights were delayed because passenger needed to be evacuated and re-screened when the incident was over.[452] Events in one part of the airport will affect other areas, hence, disrupting the system and possibly critical nodes.[453] Therefore, risk assessments need to consider the impact to the entire system.

3. Recommendation: Risk Models

In 2012, RAND published a comprehensive evaluation of TSA's Risk Management Tool (RMAT).[454] Morrel et al. admit that before RMAT began, "TSA's approach to risk analysis and risk management was rudimentary" and that this new tool "led TSA to increasingly sophisticated understandings of the nature of terrorism threats, vulnerabilities, and consequences."[455] It is a useful analytical tool for simulating terrorist behavior and attack success. However, the tool is not without flaws. The researchers advise, "input data requirements exceed what subject matter experts or science can estimate with precision, and the imprecision of those estimates is subject to unknown

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[451] Lundberg and Willis, "Assessing Homeland Security Risks."

[452] "'You're Going to Have to Shoot Me' Man Says before Launching at Cop in US Airport," Yahoo and Agencies, June 12, 2016, https://au.news.yahoo.com/world/a/31819778/youre-going-to-have-to-shoot-me-man-says-before-launching-at-cop-at-us-airport/.

[453] R. Guimerá, and L.A.N. Amaral, "Modeling the World-Wide Airport Network," *European Physical Journal B.* 38, no. 2 (2004): 381, https://doi.org/10.1140/epjb/e2004-00131-0.

[454] Morral et al., *Modeling Terrorism Risk to the Air Transportation System*.

[455] Morral et al., xviii.

sources and ranges of error."[456] They propose that it can be used to address policy concerns and multiresolution modeling for provisioning resources. Hence, modeling tools should be combined with subject matter expert groups as described earlier for a holistic picture of the threat.

In 2017, the TSA published a guidance document in partnership with the General Aviation community to offer best practices to "airport owners, operators, sponsors, and entities charged with oversight of GA landing facilities, including tenants and/or users… that address general aviation security concepts, technology, and enhancement."[457] The guidance document offers a "protective measures matrix" to assist airport owners establish a baseline to assess risk and implement security measures.[458] This document is unique to others published by TSA because the recommendations include the CPTED principles of defensible space. The guidance document offers suggestions for access/key control, perimeter security/physical barriers, CCTV, technology/intrusion detection systems, lighting, and signage. For example, for protective lighting, several options should be considered for effective usage: continuous lighting, standby lighting, movable lighting, emergency lighting and solar power lighting.

4. Recommendation: Physical Structures and Technology

The case studies of Brussels, Los Angeles, and Glasgow illustrated that the physical built materials of an airport play a significant role in mitigating and deterring the threat. Wherever possible, blast resistant materials should be considered in airport public spaces were crowds form. Goel and Matsager describe how the shaping of buildings reduces explosion pressure, which is achieved by avoiding normal reflection. They state that there is a constant peak pressure across an exposed edge, on square-edge, and rectangular long-edge structure sections. They also observe that, "a parabolic shape or a

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[456] Morral et al., xviii.

[457] Transportation Security Administration, *Security Guidelines for General Aviation Airport Operators and Users*, Information Publication A-001, Version 2 (Washington, DC: Transportation Security Administration, 2017), 5, https://www.tsa.gov/sites/default/files/2017_ga_security_guidelines.pdf.

[458] Transportation Security Administration, 5.

cubic shape performs better than upright face façade."[459] The researches admit that with the advent of new technology and lightweight materials, various mitigation strategies for blast-resistant design can be implemented. Figure 27 demonstrates the multiple layers that may be included in structural loading for blast mitigation. Although it may not be feasible to add all these layers, the diagram provides a holistic view of assessing all the components.

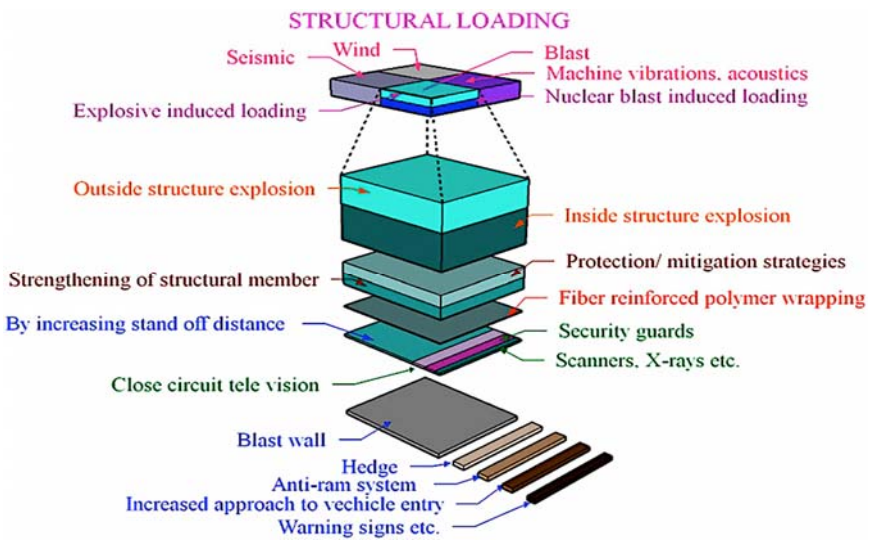

Figure 27. Blast Mitigation Strategies for Structural Loading of Buildings.[460]

The Glasgow case stressed that the newly renovated SkyHub windows were constructed of Kalwall material. The technology of the Kalwall windowpanes is different from standard glass.[461] Kalwall is an insulated structural sandwich pane with superior thermal performance that can transmit light. The material is a great alternative for airport ceiling glass replacement because it is shatterproof and lightweight, as well as aesthetically pleasing. Kalwall has been installed in many places, and a few include,

[459] Manmohan Dass Goel and Vasant A. Matsagar, "Blast-Resistant Design of Structures," *Practice Periodical on Structural Design and Construction* 19, no. 2 (2014): 04014007-4, doi: 10.1061/(ASCE)SC.1943-5576.0000188.

[460] Source: Goel and Matsagar, 04014007-4. Reprinted with permission.

[461] "Technology," Kalwall, accessed January 17, 2017, https://www.kalwall.com/technology/.

Amager Resource Center, Featherstone High School, Raleigh-Durham Airport, Georgia Tech CNES Laboratory, and South Bend Regional Airport.[462]

Companies, such as Blast Structures, offer various blast and bullet resistant products. The materials include, bullet/blast resistant doors, bullet/blast resistant frames, security glass clad laminates, bullet resistant fiberglass, blast protection and fragmentation composite.[463] They also provide portable bullet and blast resistant curtains. The curtains can be rolled up and transported and are, therefore, adaptable to the environment.[464] Bulletproof origami Kevlar shields are also adaptable because they can be folded and put away. The folds and creases of the design, along with the constructed material, provide a lightweight barrier.[465] Although products currently available on the market only protect against handguns, technology advancements in these barriers types can provide additional sources of protection. These curtains and barriers offer possible solutions for protecting queues and crowds in the airport terminal public spaces.

5. Recommendation: Robotics

Private companies are increasing the use of security robots to protect assets and infrastructure. Security robots can range from human controlled to completely autonomous or rule-based platforms. Theodoridis and Hu describe several classes of security robotics technology, which they refer to as "intelligent security robots (ISR). These include teleoperated security robots (remote controlled robots), distributed security robots (network and multiagent robots), surveillance security robots (single autonomous

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[462] "Project Reports," Kalwall, accessed January 17, 2017, https://www.kalwall.com/product-brochures/project-reports/.

[463] "Bullet Resistant Products," Blast Structures, accessed January 17, 2018, http://www.blaststructures.com/bullet-resistant-products/.

[464] "Portable Blast Curtain," Blast Structures, accessed January 17, 2018, http://www.blaststructures.com/portable-blast-curtain/.

[465] Todd Hollingshead, "BYU Engineers Built a Bulletproof Origami Shield to Protect Law Enforcement," *Intellect*, February 16, 2017, https://news.byu.edu/news/byu-researchers-built-bullet-proof-origami-shield-protect-law-enforcement.

robots); and law-enforcement robots (weaponized autonomous and semiautonomous) (see Appendix H for examples of surveillance security robots).[466]

The robots' main function is to augment business security personnel and offset costs to companies that need additional security measures. They can also capture data from the environment and send the information to a control center for further analysis and action. Capabilities include video surveillance, thermal imaging, gas and heat sensors, 3D depth cameras, facial recognition, laser radar, and radio frequency identification (RFID). Multiple companies exist that employ and deploy security robots, such as RobotTex, Gamma2Robotics, Robot Security Systems, and Knightscope Incorporated, to name a few.[467] These security robots all have mobile sensor platform technology in common.

Knightscope Incorporated is a great example of how security robots provide autonomous data capability to augment physical security. Knightscope robots have advanced 360-degree video, people and weapon detection, autonomous presence, two-way audio, thermal imaging, and license plate detection.[468] They offer four different models: the KI is for indoor and outdoor use, such as, malls office buildings, and sports arenas, K3 is for indoor use, and the K5 and K7 are for outdoor use, such as parking lots, corporate campuses, and hospitals. The K7 looks like a miniature vehicle. The robots autonomously patrol the environment to detect anomalies. They record video and audio information and can transmit pre-recorded announcements, which is great for crowd management. Knightscope rents the robots to consumers for about $7.00 an hour and it also offer services to the Knightscope Security Operations Center (KSOC), which is a browser-based interface that allows consumers to access real-time data through their mobile devices or computers.[469]

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[466] Theodoros Theodoridis and Huosheng Hu, "Toward Intelligent Security Robots: A Survey," *IEEE Transactions on Systems, Man, and Cybernetics—Part C: Applications and Reviews* 42, no. 6 (2012): 1221–1222, doi: 10.1109/TSMCC.2012.21.2198055.

[467] "Robot Security Systems 24/7 Safety and Security," Robot Security Systems, 2016, http://www.robotsecuritysystems.com; "Meet the New Face of Security," Gamma 2 Robotics, 2017, http://www.gamma2robotics.com.

[468] "Services," Knightscope Incorporated, accessed January 18, 2017, https://www.knightscope.com/services/.

[469] "CEO Interview-Knightscope, Inc.," YouTube Video, 7:18, posted by SCN Corporate Connect, January 28, 2017, https://www.youtube.com/watch?v=fjJPH3jzfVE.

According to Schiller, there "are now two dozen K5s in operation in the Silicon Valley area, including on corporate campuses, shopping malls, and data centers."[470] He asserts that the robots can audio sense breaking glass, honking cars, and screaming noises. He uses the analogy that a security guard sits for 45 minutes and patrols for five, whereas, the robots will patrol for 45 minutes and electrically charge for five minutes.[471] He also argues that the robots are more cost-effective than paying guards $25 an hour or the minimum wage. Although the latter argument may be true, the robots have not achieved the level of full screening autonomy in the airport environment. Therefore if this option were considered, they would continue to augment personnel security and law enforcement. Nevertheless, they can provide effective security redundancy and deterrence from adversaries.

The potential application of this technology is its use to protect crowds in the airport environment. The K3, for example, can be used to secure the inside terminals around crowded areas at the ticket counters, TSA checkpoint queues, and baggage claim areas by providing face recognition, explosives detection, and alarms and alerts. Whereas the K5 can be used in outside areas to detect suspicious vehicle plates, broken airport fences, and threats in passenger pick-up and drop off zones. Additionally, the robots are equipped with emergency alert buttons that can be useful during an active shooter event, for example, to expedite emergency response to the scene. Thermal imaging would also provide emergency responders and firefighters with potential infrastructure and aviation transportation damage. Hence, they can also serve as effective emergency response and communication tools for the aftermath of dangerous incidents.

The most advantageous capacity for robotics in airport security is their deterrence effect. The robots' command presence, video, and audio recording capabilities discourage would-be adversaries' attack. The robots' random movement also increases the terrorist risk to their operations that may also prevent the terrorist planning cycle of terrorist

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[470] Ben Schiller, "Meet the Scary Little Security Robot That's Patrolling Silicon Valley," *Fast Company*, August 13, 2015, https://www.fastcoexist.com/3049708/meet-the-scary-little-security-robot-thats-patrolling-silicon-valley.

[471] Schiller, paragraph 3.

surveillance and target selection due to the fear of being recorded and caught, thereby decreasing utility.

The Los Angeles shooting event demonstrated that passengers are often unfamiliar with an airport's layout, and therefore, law enforcement encountered problems with crowd movement and communication. The robot's ability to make audio announcements can also be utilized in the airport environment to warn individuals of perpetrators, attacks, evacuation zones, exit routes, and provide crowd management. Robots can also be used to broadcast messages to passengers about prohibited items aboard aircraft and not to leave luggage unattended. Moreover, it can alert police of any unattended bags or vehicles within the terminal area. These capabilities can potentially thwart VBIEDs or IEDs that may be concealed.

6. Recommendation: Simulation Models

Computerized simulation models provide practical alternatives to attack scenario planning for airport authorities. They offer the opportunity to test methods and assess risk before airports spend money to retrofit or build new designs. Although not perfect, the ability to generate multiple attack scenarios and outcomes provides airport operators with critical thinking skills to understand where to mitigate the risk in the airport infrastructure. Jackson et al. posit that, "when models are subject to deep uncertainties about the mechanisms producing modeled outcomes, or the input conditions affected by those mechanisms, exploratory analysis can be used to systematically look across as many combinations of parameter values as necessary to understand not an average expected outcome, but rather the input conditions under which the model produces qualitatively different outcomes."[472] They assert that in these conditions, *exploratory analysis* is required. They stress that "in the language of decision theory, policy makers should seek strategies that are flexible, adaptive, and robust."[473] Adding CPTED elements to the model can also assist in this exploration.

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[472] Jackson et al., *Efficient Aviation Security*, 114.

[473] Jackson et al., 97.

Two concepts must be defined for airport computerized simulation modes. First, crowd movement and formation within the construct of the airport environment must be assessed to provide developers with crowd flow diagrams. Second, the placement of new physical structures must also be assessed with the crowd flow because movement should not be impeded. Finally, attack scenarios should be constructed in the various areas of the space to assess impact and damage to crowd flow.

Various crowd simulation models exist in the open market. Almeida, Rosseti, and Coelho describe how multi-agent systems are used for emergency management evacuation simulations. They demonstrate how crowd herding, flocking, arching and clogging impact movement of crowds and that the multi-agent system model "allows to model each individual person with their own unique characteristics, but related with all surrounding persons, thus recreating the real world interactions among human beings."[474] As discussed in the Los Angeles after action review in Chapter III, crowd management was a critical problem. Software simulations, such as these, provide the ability to assess crowd management during an event. Moreover, Rivalcoba et al. developed a simulation system whereby they coupled real-time crowd simulation with virtual people. Their research results found that the system was able to perform this coupling successfully and revealed how simulated virtual characters react to the real-people.[475] This type of system optimization can be used to analyze the movement of virtual attackers in an airport scene.

Can simulation models prepare airport operators for terrorist attacks? Saville introduces the antiterror risk infrastructure protection model (ATRiM).[476] ATRiM is "a new computerized critical infrastructure protection system that combines the proven

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[474] João Almeida, Rosaldo Rosseti, and António Leça Coelho, *Crowd Simulation Modeling Applied to Emergency and Evacuation Simulations Using Multi-Agent Systems* (Porto, Portugal: Laboratório de Inteligência Artificial a Ciência de Computadores, Faculdade de Engenharia de Universidade do Porto, Laboratório Nacional de Engenharia Civil, 2012), 5, https://arxiv.org/pdf/1303.4692.

[475] Ivan Rivalcoba et al., "Simulated Virtual Crowds Coupled with Camera-Tracked Humans," in *Computer Vision, Imaging and Computer Graphics—Theory and Applications*, *Communications in Computer and Information Science*, vol. 550 (Chanm, Switzerland: Springer, Cham, 2015), 62–77, doi: 10.1007/978-3-319-25117-2_5.

[476] Gregory Saville, "ATRiM for Critical Infrastructure Protection," in *Randal Atlas, 21st Century Security and CPTED, Designing for Critical Infrastructure Protection*, ed. Randall I. Atlas, 2nd ed. (New York: CRC Press, Taylor & Francis Group, 2013), 296.

prevention strategies of CPTED and environmental security with the training and software package of modern technology."[477] It offers an analysis of operational and physical risk vulnerabilities by considering cascading and escalating failures. Saville defines the cascading effect as attacks to one target causing rippling effects to other similar infrastructure. He defines escalating "when one failed infrastructure escalates onto other different kinds of infrastructure."[478] For example, an attack to the airport infrastructure will impact the delivery of cargo and prevent the delivery of economic commerce goods.

Saville asserts that ATRiM delivers *analytical specificity* by prioritizing risk, particularly because not every target is a high risk. He admits that these protective measures "provide opportunities for the apprehension of terror suspects prior to the event."[479] ATRiM adds to industry critical infrastructure protection plan measures by using an advanced CPTED risk audit. It examines 12 specific CPTED strategies (see Appendix I for a full description):

> 1) territoriality, 2) access control, 3) surveillance, 4) image/maintenance 5) increase the effort to commit crime, 6) increase risks to criminal, 7) reduce factors that provoke crime, 9) social cohesion, 10) connectedness, 11) community culture, and 12) capacity threshold.[480]

It also provides catastrophe risk modeling, which have been applied to events of natural disasters.

The ATRiM software works by having an audit team input data into a handheld computer, thereby producing a geoposition and 3D visualization of the site. It is equipped with a camera, voice detection, and text field notes. Each CPTED audit category is correlated to each other. The auditor must consider physical and operational factors, surveillance of offenders, CCTV placements, and security operational requirements. When all the data is entered, the computer model risk algorithm provides a list of priority

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[477] Saville, "ATRiM for Critical Infrastructure Protection," 289.

[478] Saville, 290.

[479] Saville, 290.

[480] Saville, 294.

approaches to reduce risk at a particular location. Saville stresses, "these recommendations build a set of remediation strategies that can become the first stage of a Critical Infrastructure Protection Plan."[481] The ATRiM software can also provide an assessment of vulnerable assets and crime maps.

Although ATRiM examines critical infrastructure and not crowd protection exclusively, coupling this software with the crowd simulation models described previously would prove useful. The ATRiM software focuses on protecting critical infrastructure from bombs, arsons, product contamination, and weapons of mass destruction. Protecting the airport environment from these hazards can *de facto* provide protection toward crowds as well. The important factor to consider in all these models is how they provide protection to the terrorist target, which the case studies demonstrated is crowds and not airport critical infrastructure *per se*.

[481] Saville, "ATRiM for Critical Infrastructure Protection," 297.

V. CONCLUSION

Aviation transportation is a vital component of the U.S. and the global economy. According to the FAA's 2016 *Economic Impact Report*, "aviation accounts for more than 5% of our Gross Domestic Product, contributes $1.6 trillion in total economic activity and supports nearly 11 million jobs."[482] Aviation provides people and commerce freedom of movement to access global markets and is crucial for American prosperity and growth. As the numbers of traveling passengers grow, securing aviation transportation is as important for the customers as it is for the industry. In the 21st century, aviation is depended upon as much as technology to move this nation forward.

Post-9/11, the TSA has done a great job in securing the skies, prohibiting dangerous items from entering aircraft, and transforming to meet the needs of the evolving threat; attested to by a lack of such an attack occurring again. In recent years, however, adversaries have begun targeting crowds in the airport environment. The cases of Brussels, Los Angeles, and Glasgow provide a lens into their strategies, perception of opportunities, and level of success in their operations. To address the next threat to aviation, a national *systematic approach* is needed to protecting crowds in the airport environment. The time has come to take a collective stand to enhance STS.

The TSA's proactive approach to address the needs of screening passengers by deploying explosive detection canine handlers, visible intermodal prevention and response teams, improving RBS, and updating policies and procedures to detect and deter the terrorist threats provides additional layers to security. The challenge still remains, however, as to how to address protecting crowded places collectively in the airport construct. Airport operators and police continue to maintain authority over these areas, and current countermeasures provide little to no physical defense to mitigate an attack.

This thesis explored how environmental design principles provide the opportunity to fill the gap of securing soft targets. It evaluated and prescribed how the CPTED

[482] Federal Aviation Administration, *The Economic Impact of Civil Aviation on the U.S. Economy* (Washington, DC: Federal Aviation Administration, 2016), https://www.faa.gov/air_traffic/publications/media/2016-economic-impact-report_FINAL.pdf.

framework can better safeguard high density crowds of people in the terminal areas, such as airline check in counters, TSA passenger screening queues, and baggage claim areas. It also proposed recommendations for new and innovative solutions to environmental design that may produce more permanent cost-effective methods to protect crowds from malicious attacks, to mitigate life loss, and protect the industry and commerce. Furthermore, policies for implementing these recommendations were evaluated. A comparative analysis that examined policies of other countries that have experienced similar threats provides critical lessons and a pathway to best practices that may be applied in the United States.

A. SUMMARY OF FINDINGS

The airport authorities' most common concern about protecting soft targets is that security measures may become too restrictive and may delay travelers' processing time to onboard aircraft, which impacts airport and airline operations. Airport aesthetic appeal is another common concern because airports and airlines want to attract customers and increase business revenues. Additionally, passengers and airport customers may complain about too many security measures. In fact, Jackson et al. demonstrate that if the cost of traveling to the passenger is too high, including the time it takes to process through security measures, then travel behavior changes.[483] The aviation industry, commerce, and economy can be adversely affected if people decide to take alternative modes of transportations, such as driving, ride sharing, or rail. Frequent flyers and business travelers may decide to use computer technology instead of face-to-face meetings. Concerns about little or ineffective security, likewise, changes passenger behavior. For example, after 9/11, people were hesitant to fly because of security concerns, and this hesitation was a detriment to the aviation industry and national economy. Hence, a balanced approach needs to be implemented so that the security is not too restrictive but is also effective.

The analysis of the case studies demonstrated the need for this balanced approach. New security measures are needed as the threat picture changes. The case studies

[483] Jackson et al., *Efficient Aviation Security*, 45.

demonstrated that after the attacks occurred, the airports took drastic steps to change terminal infrastructure that included adding environmental countermeasures, such as blast proof materials, bollards, and additional access control measures. In the airports were IED attacks occurred, such as Brussels and Glasgow, passenger drop-off and pick up zones were delineated and distanced from the terminal building structure. Additionally, canine and police presence increased within the public spaces in all cases.

The thesis proposes a more proactive approach rather than a reactive one. The comparative policy analysis exemplified that EU countries, such as the United Kingdom and Brussels are taking the lead in protecting crowds. Policies in these countries, such as CONTEST and ASAID, have put soft targets as priorities for planning and risk mitigation strategies in airports, as well as communities. In the United Kingdom, for example, protecting crowded spaces is one of the Home Office's main priorities. The standardization of the RAG and SEG, and projects, such as Argus and Griffin, led environmental engineers and designers to innovate new methods to improve STS. Lessons learned from these initiatives can prove fruitful in the U.S. homeland.

In the United States, coalitions and policies to address soft targets are continuing to develop. Many airport operators are renovating as airport terminal infrastructure is aging. Airport operators have the primary responsibility for protecting the traveling public. Jackson at el. recognize that "costs paid by local airport authorities vary, and systematic data are difficult to obtain."[484] Airport improvement plans typically involve stakeholders, such as airport management, airlines, travel customers, and concessionaires.[485] The Air Transport Association (ATA), the International Air Transport Association and special interest groups may also be considered in the design process.

Stakeholder and government agency input differs among various airports in the United States. For example, the FAA involvement is mandated per 14 CFR Part 77(9) to ensure all airports conform to environmental and aircraft and airfield navigational

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[484] Jackson et al., *Efficient Aviation Security*, 44.

[485] National Academies of Sciences, Engineering, and Medicine, *Airport Passenger Terminal Planning and Design, Volume 1: Guidebook* (Washington, DC: National Academies Press, 2010), 17, https://www.nap.edu/download/22964.

restrictions. On the other hand, although the TSA is an important stakeholder for airport security and regulatory oversight of the airport security plans, it is not offered the authority to mandate any requirements. Instead, airport stakeholders may consider the TSA's recommendations as provided, for example, in the *Recommended Security Guidelines for Airport Planning, Design, and Construction*.[486]

The authors of the *Recommended Security Guidelines* recognize that, "transportation facilities such as airports, subways, train stations and bus stations are all potential targets of terrorism not only because they are vital to a stable economy and to the operation of countless businesses, but they are very visible, accessible, high-profile facilities filled with high a density of people."[487] The guidance document offers risk management plans for security design, target standoff, physical protection features, risk prioritization measures, and integrated strategies that combine these elements.[488] It is critical for airport operators and stakeholders to consider these environmental design principles in the renovation and new builds of terminal structures. These public-private partnerships can only strengthen the United States' overall security posture.

The recommendations provided in this thesis compliment the aforementioned counter-terrorism strategies toward soft targets. They provide an analytical approach to how terrorist perceive and select the target. Advances in security screening employed by the TSA have significantly improved to detect and deter the threat. Due to the evolving threat, however, airport security must be re-imagined in the public sphere by implementing people-centric methods. In other works, security should be about *crowd-protection* first.

All risk cannot be eliminated. Adding human resources, such as police and canine units, provide a great deterrent toward an adversary. However, they are expensive to maintain. Their practices and jurisdiction are also not uniform among U.S. airports

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[486] National Academies of Sciences, Engineering, and Medicine, *Airport Passenger Terminal Planning and Design*, 18–19.

[487] National Safe Skies Alliance, Inc., "Recommended Security Guidelines for Airport Planning, Design, and Construction," B–1.

[488] National Safe Skies Alliance, Inc., B–2.

nationwide. Introducing environmental design principles in the airport public spaces offers alternative methods for a more consistent and permanent solution. Applying CPTED principles in critical pinch-points also reduces the overall costs of target hardening. Methods, such as reconfiguring passenger queues, using technology to reduce crowds checking-in luggage at airline ticket counters, and limiting access to baggage claim areas, may afford significant improvement in deterring adversaries. Additionally, optical illusions in design architecture can further enhance risk mitigation.

Physical structures that minimize threat impact provide resiliency and feasibility to boost continuity of operations. Limiting potential debris and incorporating blast proof and bulletproof structural materials not only saves lives and minimizes injuries, but it also acts as a deterrent. Movable barriers, such as bulletproof curtains, provide flexibility to adapt to the threat. Additional material, such as Kalwall windowpanes, limit debris from explosive aftershock. An overall national plan needs to stress the incorporation of these physical elements to deter the adversary's perception of selecting crowds as targets.

The case studies of Brussels, Los Angeles, and Glasgow airports demonstrated that a national plan for conducting standardized risk assessments is required for terminal public areas. In Glasgow, for example, risk assessments continued to occur years after the 2007 attack was over. The newly renovated terminal vehicle routing and ANPR technology is a testament to this fact. In the United Kingdom, the RAG and SEG groups provide airport risk assessments throughout the nation. In Los Angeles, threat and vulnerability assessments groups are comprised of partners from the police, airport, airlines, architectural, and construction contractor groups. These comprehensive risk assessments provide a holistic approach to the national aviation transportation security structure.

Technology, simulation models, and robotics provide cost-saving alternatives to enrich threat mitigation strategies. Computer models, such as ATRiM, offer opportunities to develop CPTED principles into the airport infrastructure. Airport stakeholders, the TSA, airlines, and police can critically assess the overlay of risk mitigation tactics and implement new elements in the terminal public areas most prone to crowds. For example, adding turnstiles in the baggage claim areas or pre-TSA queues can provide an additional

layer of access control to limit adversaries' approach and operational planning. Integrating robotics into this construct can further this goal.

The significance of adding CPTED environmental design elements not only decreases crime, but it also averts terrorist planning. The case studies have demonstrated that the terrorists perceived that the target was easy to attack and cause significant damage. The adversaries' perceptions can be altered by implementing measures to protect the soft targets; hence, increasing operation risk and deterring the attack objective. Environmental design can effectively augment the police and canine presence, and in their absence, can provide a more cost-effective and permanent method than employing additional human resources to patrol these public areas. Most importantly, they offer the ability to mitigate an explosive or gunfire impact, if one does occur. In essence, these factors increase infrastructure resiliency, mitigate life loss, and improve continuity of operations. The ultimate result is enhancing aviation transportation security nationwide.

B. LIMITATIONS

The thesis is limited to a descriptive analysis of case studies where the attacks caused significant infrastructure damage or life loss. Cases where attack impact was not successful due to the implementation of CPTED principles were not examined and therefore generalizations to all airports cannot be applied. CPTED is often used in communities and the crime prevention field where it has been proven effective.[489] However, it is difficult to discern which airports actively engage the implementation of environmental psychology and CPTED in the airport construct. These principles have not been thoroughly tested in the airport terminal structures where crowds form. Therefore, research is needed to validate its application. Additionally, this thesis is limited in the causal inference between applying environmental design elements and deterrence of terrorist behavior in airports. Empirical evidence is lacking in this area, and further examination into this subject is required.

[489] Sakip, Johari, and Salleh, "The Relationship between Crime," 629; City of Virginia Beach Municipal Center, *Crime Prevention through Environmental Design, General Guidelines for Designing Safer Communities* (Virginia Beach, VA: City of Virginia Beach Municipal Center, 2000), https://www.vbgov.com/government/departments/planning/areaplans/Documents/Citywide/Cpted.pdf.

C. IMPLEMENTATION

CPTED engineering and architectural components can become very costly depending to what level they are integrated. This thesis does not provide a cost-benefit analysis, and it would be helpful to evaluate these concepts before implementation. Computer simulation models may assist in minimizing these costs before implementation because they offer the ability to analyze the outcomes. In the short-term, they provide the ability to assess the environment, navigate through recommended countermeasures, and evaluate attack outcome on crowds and infrastructure. Additionally, they may provide the ability to conduct a cost-benefit analysis of aviation transportation impact, such as diverted and grounded airplanes, revenue lost due to airport shutdown, and business operations.

In the midterm, piloting physical structure models, (i.e., blast proof and bulletproof materials, elongated queue designs, optical illusions, turnstiles, and robotics) may provide the ability to assess utility that may require invested time and resources to evaluate their effectiveness, which may also prove to be costly. This process can also be challenging because each airport construct is different; hence, engineering, architectural, and explosive experts may need to be involved. The sensitivities of dealing with the traveling public must also be considered. Since crowds accumulate in airports on a daily basis, navigating through these constraints will have to be thoroughly planned out.

The long-term solution involves an enriching and continuous relationship between the public and private sector. This process may also include changing federal, state, and industry policies for crowd protection. Enhancing these partnerships for a collaborative, holistic, and systematic approach toward STS involves many government agencies and industry partners. This approach can be very time consuming, and the airport owners and airlines may feel impeded in business growth opportunities. The question is who will incur the cost to this added security measure? Is it cost-effective or necessary? Ultimately, the policy change or added security measures must be welcomed by the consumers, the traveling public. For these recommendations to be feasible, everyone must first agree that STS is a priority and a real concern.

D. FUTURE RESEARCH

Historically, CPTED principles have been applied to community settings to prevent crime. Future research must test and validate that these same principles can be applied in the closed system of aviation transportation. First, they must validate that they are cost-effective to 1) save lives, 2) minimize human injury, 3) improve airport infrastructure resiliency, and 4) mitigate economic losses to the aviation industry. Future research should test which recommended elements of CPTED are most applicable in the airport setting without compromising the traveler experience. A comparative analysis between environmental design and policing would also provide insight into a cost effective and balanced approach to protecting soft targets.

Future research in computer simulation models and physical structure models may help glean into terrorists' target perception and attack impact. The research should focus on areas of crowd formation, perception of opportunistic attacks, and the outcome of those attacks. These simulation models can produce accurate risk assessment tools to focus on the pinch-points where countermeasures need to be applied.

Knowing how to protect crowded spaces effectively in the airports' public terminals cannot only save lives, but also deters adversaries. If applied strategically through a *systematic approach*, STS can prove to be cost-effective to aviation transportation. Mitigating losses to aviation transportation positively impacts this nation's national economy and commerce. Globally, this country has witnessed policy initiatives and changes due to attacks on crowds in the airport environment. As crowds continue to increase in airports nationwide, STS will play an important role in ensuring the freedom of movement for people and commerce.

APPENDIX A.

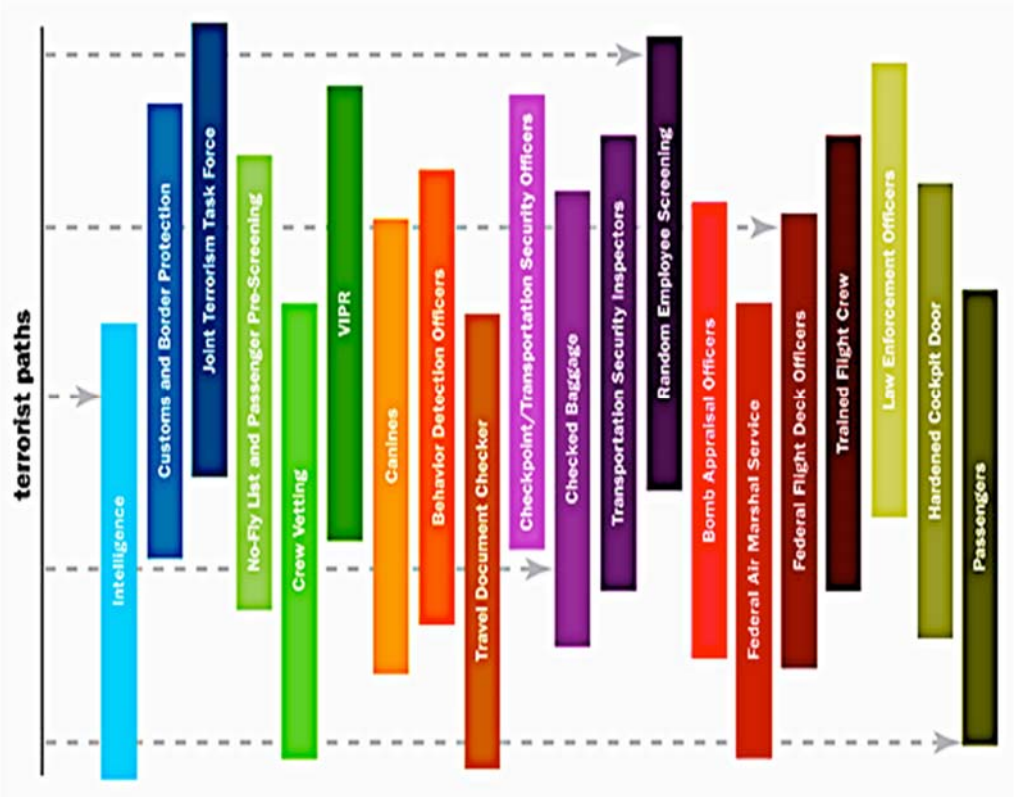

Figure 28. 20 Layers of U.S. Aviation Security.[490]

[490] Source: William Johnstone, "Passenger Aviation Security Layers," *Elsevier SciTech Connect*, October 6, 2015, http://scitechconnect.elsevier.com/passenger-aviation-security-layers/.

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APPENDIX B.

The United Kingdom's Strategy for Countering Terrorism (CONTEST).[491]

- *Pursue:* to stop terrorist attacks
- *Prevent:* to stop people becoming terrorists or supporting terrorism
- *Protect:* to strengthen our protection against a terrorist attack
- *Prepare:* to mitigate the impact of a terrorist attack

[491] Controller of Her Majesty's Stationery Office, *CONTEST*, 10.

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APPENDIX C.

Figure 29. Brussels Airport Map.[492]

[492] Source: "BRU Airport Map, BRU Terminal Map," AirportPedia.net, accessed November 18, 2017, https://www.airportpedia.net/airport/bru/map.

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APPENDIX D.

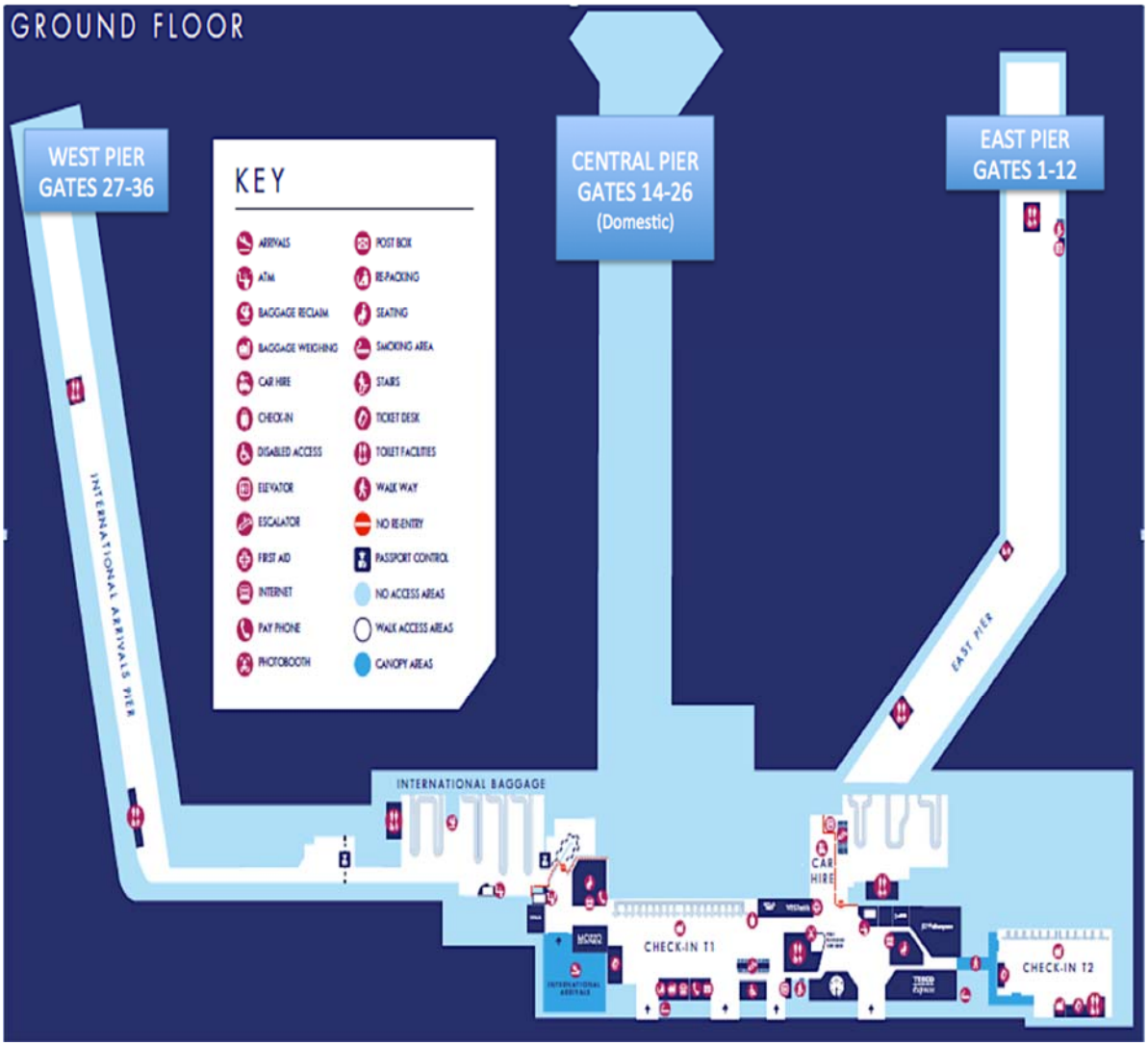

Figure 30. Glasgow Airport.[493]

[493] Adapted from Glasgow Airport, "Info, Airport Maps." Reprinted with permission.

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APPENDIX E.

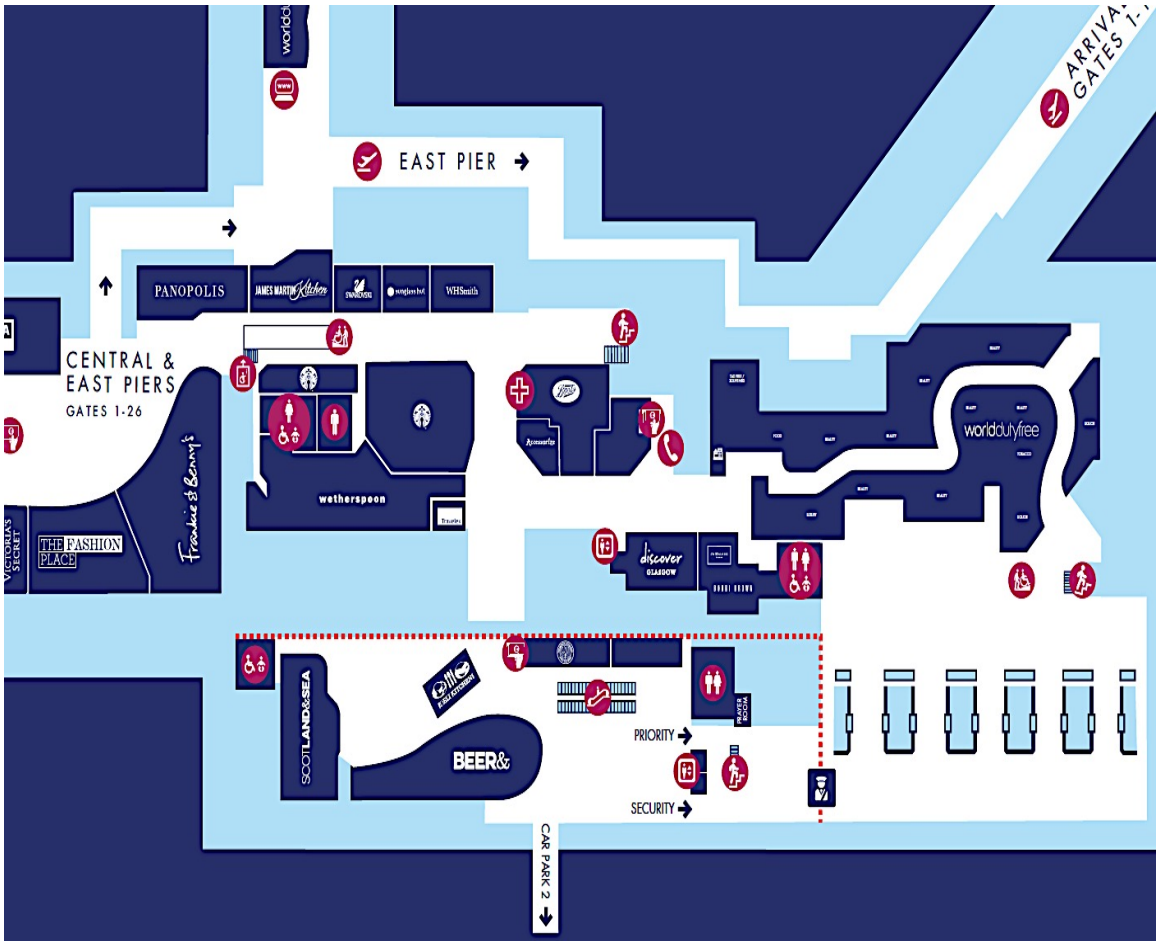

Figure 31. Glasgow Airport: Main Terminal (T1) and Smaller Terminal (T2).[494]

494 Source: Glasgow Airport, "Info, Airport Maps." Reprinted with permission.

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APPENDIX F.

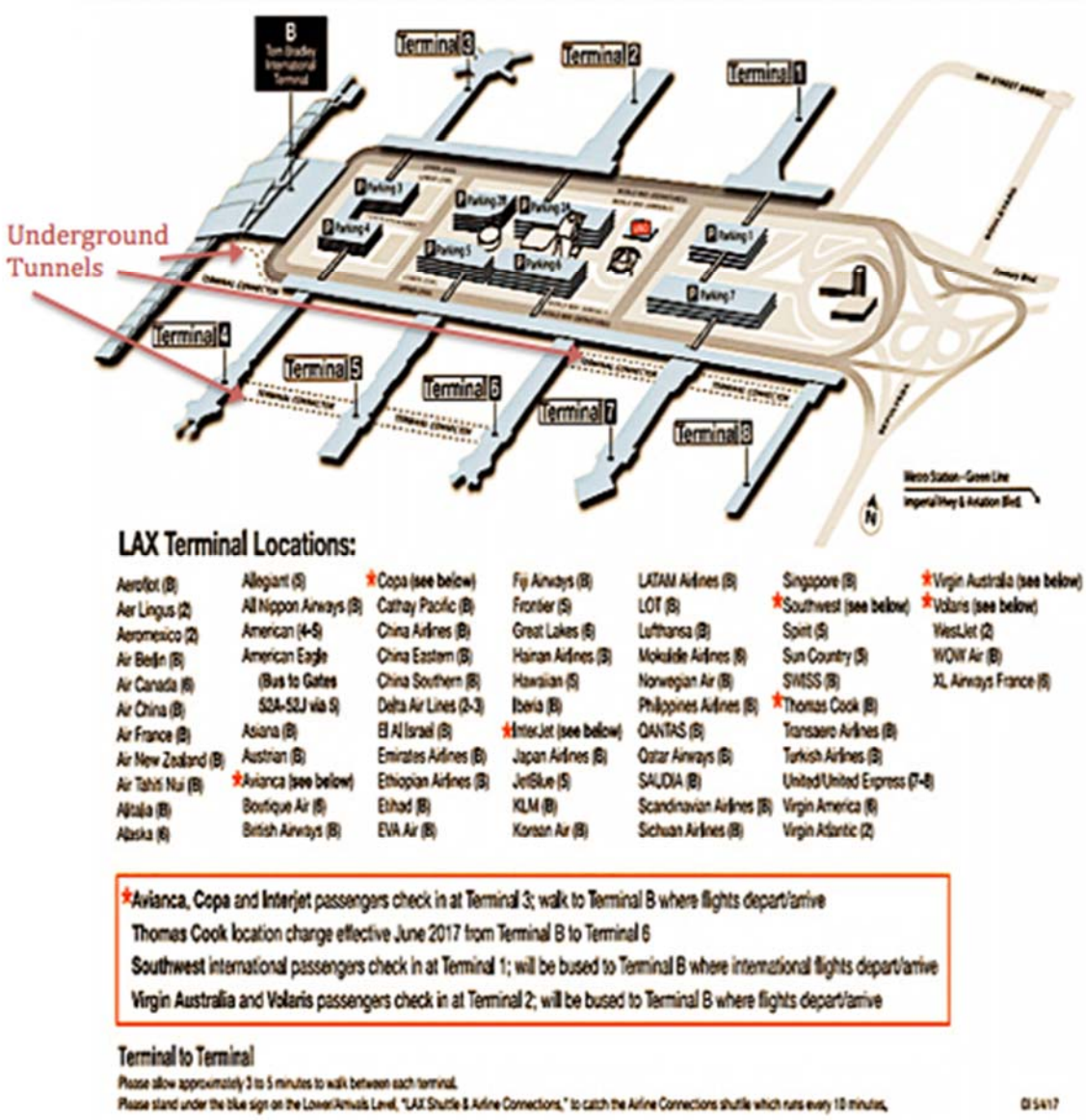

Figure 32. Los Angeles Airport Terminals.[495]

[495] Source: "A Basic Guide to Los Angeles International Airport," Discover Los Angeles, last updated December 14, 2017, https://www.discoverlosangeles.com/blog/basic-guide-los-angeles-international-air port. Reprinted with Permission.

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APPENDIX G.

Counter-terrorism design principles	Examples of measures
Better blast resistance	• External barriers or a strengthened perimeter to prevent a penetrative (ramming) or close proximity (parked or encroachment) attack; • Use of building materials which reduce the risk of fragmentation including blast resistant glazing and structural design which reduces the risk of building collapse; and • Install doors and locks which are better able to withstand entry from armed intruders and provide robust ground floor facade material, which together will help to provide cover for people caught up in a firearms attack.
Better building management facilities	• Entrance arrangements which resist hostile entry; • The separation of general heating, ventilation and air conditioning systems for entrance areas, delivery areas and mailrooms from those occupying the main occupied spaces • Air intakes that are in a secure area and above the first floor level; • Hazardous material stores that are at a safe distance from the building and; • Communications systems (e.g. public address systems) installed to pass on advice to those caught up in a firearms attack.
Better traffic management and hostile vehicle mitigation measures	• Structural measures that prevent access to, or close proximity of, unscreened vehicles to the building or space; and • Measures that reduce the speed of vehicles approaching the site or its defences, like bends or chicanes
Better oversight	• Clear lines of sight around a building • Absence of recesses on the façade or elevations of a building; • Uncluttered street furniture • Well maintained and managed litter-free building surrounds that reduce the opportunity for suspicious hidden items and suspect activity to go unnoticed; • CCTV and security guarding to provide formal oversight; • Orientating the building so that it overlooks public space and neighbouring buildings to support informal oversight by those who use and visit the location; and • Well managed access points and reception facilities that offer less opportunity for intruders to go undetected and may deter them from taking further action
Better search and screening measures	• Provision of sufficient space at vehicle entrances to allow proportionate screening of vehicles (and their occupants / loads) as and when the threat dictates; • Provision of sufficient space at pedestrian entrances to allow proportionate screening of people and their possessions as and when the threat dictates; • For higher risk sites, consider off-site screening of deliveries and mail.

Figure 33. Recommendations for Counter-Terrorism Protective Measures.[496]

[496] Source: Home Office, *Protecting Crowded Places*, 12. Reprinted with permission.

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APPENDIX H.

Reference	Application	Architecture	Platform	Core Sensor
Gilbreath et al. 1988-2004 [33, 34, 35, 36, 37, 38, 2, 39, 3, 40, 4, 41, 42]	Intruder detection.	Generic modular robotic architecture using a RF-link.	ModBob robot	Ultrasound, IR, Microwave and Stereoscopic video motion detectors
Everett et al. 1996 [38, 43]	Motion and intruder detection via multiple behaviours.	Sensor fusion algorithm.	Denning Sentry robot	Ultrasound, Dopplers, Microwave motion detectors
SSC San Diego. 2000 (survey) [20]	Surveillance in hostile environments.	1st Gen: Modified Lemming platform, 2nd Gen: Tactical Adjustable Robot.	Man-Portable Robotic System URBOT	Forward and rear-looking video cameras with IR, High-speed digital RF video link, Microphone
Birk et al. 2002 [44]	Deployment of semi autonomous surveillance behaviours.	Internet/Intranet wireless technology with telematics services.	RoboGuard	Video, Odometry
Kollar et al. 2003 [45]	Tracking/tagging victims and rescuing situation assessment.	A sense-to-act architecture with Monte-Carlo SLAM, and Kalman-based 3D map construction.	Mabel robot	Vision, Speech, Laser, Odometry
Carnegie et al. 2004 [46]	Objects and intruder detection; security ID-card identification.	Scenario based intruder handler.	MARVIN robot	Camera, Microphone, Laser
Chong et al. 2005 [8]	Surveillance decision planning and intruder detection.	Dynamic Bayesian network with decision processes.	Simulated environment	Directed acyclic graph
Treptow et al. 2005 [9]	Remote surveillance in indoor environments; people identification and patrolling capabilities.	Particle filters with simplistic elliptic models.	Peoplebot robot	Thermal camera
Biber et al. 2005 [18]	Patrol strategies, map acquisition, object guarding, intruder detection, and alarming.	World model construction through a graph-cut stereo algorithm.	Peoplebot robot	Omni-directional camera, Laser
Liu et al. 2005 [47]	Intruders detection assessments and following.	Invariant face recognition algorithm using the MAGOR model.	P3-DX8 iBotGuard robot	Visual, Ultrasound
Kim et al. 2009 [48]	6-axis motion simulator for testing mobile surveillance UGV robots.	Multibody dynamics and control co-simulation model.	Virtual mobile surveillance robot	Odometry

Figure 34. Examples of Surveillance Security Robots.[497]

[497] Source: Theodoridis and Hu, "Toward Intelligent Security Robots," 1222. Reprinted with permission.

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APPENDIX I.

ATRiM Audit Activities for Assessing Bomb Risks

B1—Territoriality	How are vulnerable areas on site supervised or controlled by employees, and by security for the prevention of bombings?
	Are semiprivate areas used demarcated to separate the private areas from the public?
	Do areas on site provide territorial control to prevent bomb placement?
B2—Surveillance	Are there adequate perimeter, rooftop, parking lot, and passageway lighting to observe potential bomb locations?
	Are there vision barriers that will hinder or help sightlines to observe bombers before they become a risk?
	Are there good natural surveillance sightlines in public areas such as parking lots?
B3—Access controls	Are there adequate zone controls on entranceways such as passes for visitors?
	Are passes collected and recorded on exit?
	Is there a balance between security fencing, cement barriers to bomb distance specifications, and good visibility for security?
B4—Image and maintenance	Is there adequate cleaning and maintenance on site to remove flammable or combustible material for bombs?
B5—Increase effort to commit	Do features on site provide opportunities for bombings, such as window boxes or landscaping features where bombs might be concealed?
	Is there hardening of vulnerable targets on site, such as protecting electrical systems, panel boards, circuit breakers, and power relays from damage or bombings?
B6—Increase risks of getting caught	Are there security or police patrols?
	Are there identification badge controls?
	Are there electronic monitoring devices into secure areas?
B7—Reduce rewards for crime	Can vulnerable assets on site be removed or concealed?
	Are there any possible benefits to terror attack on site that can be denied?
B8—Cohesion	Is there positive interaction between security/police and capable guardians on site and do they effectively cooperate to monitor security?
	Are there security education and training programs for staff?
B9—Neighborhood connectedness	Do employees have opportunities to monitor visitors on site; do they speak to them, find out who they are?
	Are outside groups involved with the site in any positive way so they can help with security?
	Are there clear and specific protocols for cooperating with outside enforcement agencies?
B10—Community culture	How is staff morale and how does it affect participation in infrastructure protection?
B11—Capacity threshold	Do all employees, staff, or organizational members participate in infrastructure protection, or only a few?
	Can security information about potential risks be employed to create a critical mass of organizational members who are committed to infrastructure protection?

Figure 35. CPTED Strategies.[498]

[498] Source: Saville, "ATRiM for Critical Infrastructure Protection," 296. Reprinted with permission.

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LIST OF REFERENCES

3D REID. "Projects/ SkyHub, Glasgow Airport." 2015. https://www.3dreid.com/projects/skyhub-glasgow-airport/.

ABC News. "Shooting Rampage at Los Angeles: How It Happened." YouTube video, 7:21. November 1, 2013. https://www.youtube.com/watch?v=XZZD4TAn644.

Airflights.To. "Glasgow Airport Terror Attack." Accessed February 3, 2018. http://www.airflights.to/Airports/UK/Glasgow-Airport.php5.

Airport Technology. "Glasgow Airport Skyhub Project, Scotland." Accessed November 23, 2017. http://www.airport-technology.com/projects/skyhub/.

Airport World. "Asset Protection." November 15, 2009. http://www.airport-world.com/features/safety-security/723-asset-protection.html.

AirportPedia.net. "BRU Airport Map, BRU Terminal Map." Accessed November 18, 2017. https://www.airportpedia.net/airport/bru/map.

Airports Council International Europe. "ACI EUROPE Letter 27 April 2016. Ministers Jan Jambon & François Bellot—Landside Security Measures." Accessed October 14, 2017. https://www.aci-europe.org/policy/position-papers.html?view=group&group=1&id=4.

Akers, Ronald L. "Rational Choice, Deterrence, and Social Learning Theory in Criminology: The Path Not Taken." *The Journal of Criminal Law and Criminology (1973–)* 81, no. 3 (1990): 653–676. http://www.jstor.org/stable/1143850.

Alfred, Charlotte. "What the Bombs Used in Brussels Reveal about the Attacks." *Huffington Post*, March 23, 2016. https://www.huffingtonpost.com/entry/bombs-brussels-attacks_us_56f2a25fe4b0c3ef52174c1d.

Allen, Jonathan. "Suspected L.A. Airport Gunman Planned 'Suicide' Mission: Congressman." *Reuters*, November 2, 2013. https://www.reuters.com/article/us-usa-california-airport/suspected-l-a-airport-gunman-planned-suicide-mission-congressman-idUSBRE9A00RS20131103.

Almeida, João, Rosaldo Rosseti, and António Leça Coelho. *Crowd Simulation Modeling Applied to Emergency and Evacuation Simulations Using Multi-Agent Systems*. Porto, Portugal: Laboratório de Inteligência Artificial a Ciência de Computadores, Faculdade de Engenharia de Universidade do Porto, Laboratôrio Nacional de Engenharia Civil, 2012. https://arxiv.org/pdf/1303.4692.

Aradau, Claudia. "'Crowded Places Are Everywhere We Go': Crowds, Emergency, Politics." *Theory Culture & Society* 32, no. 2 (2015): 155–175. doi: 10.1177/0263276414562429.

Asal, Victor H., Karl Rethemeyer, Ian Anderson, Allyson Stein, Jeffrey Rizzo, and Matthew Rozea. "The Softest of Targets: A Study on Terrorist Target Selection." *Journal of Applied Security Research* 4, no. 3 (2009): 258–278. doi: 10.1080/19361610902929990.

Associated Press. "Cops Took 1.5 Hours to Organize Response to LAX Shooting." March 18, 2014. https://nypost.com/2014/03/18/cops-took-1-5-hours-to-organize-response-to-lax-shooting/.

——. "Recent Airport Attacks at a Glance." June 29, 2016. https://apnews.com/4950118bb7e944c6b3bc8045b39bd24e.

Atherton, Kelsey. "Landscape Architects Now Design for Mass Shootings." *Verge*, October 13, 2017. https://www.theverge.com/2017/10/13/16467716/mass-shootings-science-survival-studies-terrorism-crowds.

Atlas, Randall I., ed. *21st Century Security and CPTED, Designing for Critical Infrastructure Protection and Crime Prevention*. Boca Raton, FL: Taylor & Francis Group, 2008.

Atlas, Randall I., and Tony DiGregorio. "Designing for Explosive Resistance." In *21st Century Security and CPTED, Designing for Critical Infrastructure Protection and Crime Prevention*, edited by Randall I. Atlas, 187–198. Boca Raton, FL: Taylor & Francis Group, 2008. https://libsearch.nps.edu/vufind/Record/1124538.

Aviation Knowledge. "TSA Layered of Security." Accessed August 21, 2017. http://aviationknowledge.wikidot.com/aviation:security-layers.

Aviation Security Committee. *Airport Landside Security, Position Paper*. Bruxelles, Belgium, Airports Council International Europe, 2016. https://www.aci-europe.org/policy/position-papers.html?view=group&group=1&id=4.

BBC News. "Behind the London-Glasgow Plot." December 16, 2008. http://news.bbc.co.uk/2/hi/uk_news/7772925.stm.

——. "Brussels Explosions: Devastation and Chaos after Attacks." March 22, 2016. http://www.bbc.com/news/world-europe-35870273.

——. "Brussels Explosions: What We Know about Airport and Metro Attacks." April 9, 2016. http://www.bbc.com/news/world-europe-35869985.

——. "Brussels Raid: Paris Suspect Addeslam's Fingerprints Found in Flat." March 18, 2016.

——. “Glasgow Airport Plans Expansion.” Last updated December 28, 2009. http://news.bbc.co.uk/2/hi/uk_news/scotland/8431770.stm.

Belgian Civil Aviation Authority, Federal Public Service Mobility and Transport, and Belgium Air Accident Investigation Unit. *Belgium Aviation Safety Programme*, version 1.0. Brussels: Federal Public Service Mobility and Transport, 2015. https://mobilit.belgium.be/sites/default/files/downloads/Belgium%20Aviation%20Safety%20Programme_v1.0.pdf.

Belgian Federal Government. “Ministers, FPS Chancellery of the Prime Minister.” Accessed August 21, 2017. http://www.federal-government.be/en.

Belgian Rail. “Gates at Brussels Airport- Zaventem Station.” Accessed November 20, 2017. http://www.belgianrail.be/en/stations-and-train/airport-connections/gates.aspx.

Bellot, François. “Ministre de la Mobilité, chargé de Belgocontrol et de la Société nationale des chemins de fer belges.” Accessed August 21, 2017. http://bellot.belgium.be/fr.

Berejikian, Jeffrey D. “A Cognitive Theory of Deterrence.” *Journal of Peace Research* 39, no. 2 (2002): 165–183. doi: 10.1177/0022343302039002002.

Berman, Eli, and David D. Laitin. *Hard Targets: Theory and Evidence on Suicide Attacks*. Working Paper 11740. Cambridge, MA: National Bureau of Economic Research, 2005. doi: 10.3386/w11740.

Big Story. “Recent Airport Attacks at a Glance.” June 28, 2016. http://bigstory.ap.org/article/4950118bb7e944c6b3bc8045b39bd24e/recent-airport-attacks-glance.

Binder, Georges, Cleveland Moffett, and Henri Montois. *Montois Partners: Selected and Current Works*. The Master Architect Series, vol. IV. Mulgrave, Victoria: Images Publishing Group, 2001.

Blast Structures. “Bullet Resistant Products.” Accessed January 17, 2018. http://www.blaststructures.com/bullet-resistant-products/.

——. “Portable Blast Curtain.” Accessed January 17, 2018. http://www.blaststructures.com/portable-blast-curtain/.

Bloomberg. “Rethinking Airport Security after the Brussels Attacks.” YouTube video, 1:10. March 29, 2019. https://www.youtube.com/watch?v=vefK5nVK1gU.

Bontinck Architecture and Engineering. “Brussels Airport, Zaventem.” Accessed November 20, 2017. http://www.bontinck.biz/en/projects/non-residential/1971-brussels-airport.

Botelho, Greg, and Steve Almasy. "Raid of Belgian Building Tied to Paris Terror Attacks Ends with 1 Dead." CNN, March 15, 2016. http://www.cnn.com/2016/03/15/europe/brussels-paris-attacks-shots-fired/index.html.

Brocklehurst, Steven. "The Day Terror Came to Glasgow Airport." BBC News, June 30, 2017. http://www.bbc.com/news/uk-scotland-40416026.

Brussels Airport. "About Brussels Airport." April 4, 2017. https://www.brusselsairport.be/en/corporate/bru.

——. "Additional Security Measures Apply to Ensure Your Safety." Accessed October 15, 2017. https://www.brusselsairport.be/en/passngr/deppax/secmeasures.

——. "Brussels Airport Terminal." Accessed November 17, 2017. https://www.airport-brussels.com/terminal.php.

——. "Connecting Belgium to the Future, Terminal & Airfield, Brussels Airport 2040." Accessed November 21, 2017. https://www.brusselsairport2040.be/en/vision-2040/63/2d-plans.

——. "Connector, Architecture." February 5, 2015. https://www.brusselsairport.be/en/corporate/connector/connstories/55342.

——. "Connector, Introduction." Accessed November 21, 2017. https://www.brusselsairport.be/en/corporate/connector/connhome.

——. "Dropping Off & Picking Up Passengers." Accessed October 15, 2017. https://www.brusselsairport.be/en/passngr/to-from-brussels-airport/pickupdropoff/.

——. "Dropping Someone Off by Car." Accessed October 15, 2017. https://www.brusselsairport.be/en/passngr/to-from-brussels-airport/pickupdropoff/paxdropoff.

——. "European EASA Airport Certificate for Brussels Airport Confirms High Level of Safety in Infrastructure and Operational Processes." August 2017. https://www.brusselsairport.be/pressroom/european-easa-airport-certificate-for-brussels-airport/.

——. "Following a European Tender, Brussels Airport Chooses G4S and ICTS as Its Security Partner for 2018." October 24, 2017. https://www.brusselsairport.be/pressroom/following-a-european-tender-brussels-airport-chooses-g4s-and-icts-as-its-security-partners-for-2018/.

——. "Map of Departures Hall." Accessed September 21, 2017. https://www.brusselsairport.be/en/passngr/at-the-airport/deplevel.

——. "Modernizing Brussels Airport." 2017. https://www.brusselsairport.be/en/corporate/history/zaventem2.

——. “Monthly Traffic Figures.” Accessed November 21, 2017. https://www.brusselsairport.be/en/corporate/statistics/monthly-traffic-figures.

——. “Tips for a Smooth Departure.” Accessed November 17, 2017. https://www.brusselsairport.be/en/passngr/deppax/tipstricks.

——. “We Love Passengers.” Accessed November 17, 2017. https://brusselsairportinnumbers.brusselsairport.be/en#we-love-passengers.

Bruxx. “Route Pier A (A/T Gates).” Accessed November 20, 2017. https://www.bruxx.be/en/airport-info/maps. https://www.bruxx.be/en/airport-info/maps.

——. “Check-in at Desk.” Accessed November 20, 2017. https://www.bruxx.be/en/airport-info/check-in/at-the-desk.

Buchanan, Larry, and Haeyoun Park. “Uncovering the Links between the Brussels and Paris Attackers.” *New York Times*, April 9, 2016. https://www.nytimes.com/interactive/2016/03/23/world/europe/how-the-brussels-and-paris-attackers-could-be-connected.html.

Bureau of Transportation Statistics. “Table 1–3: Number of U.S. Airports(a).” Accessed February 12, 2018. https://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_01_03.html.

Burke, Jason. “Why Did the Bombers Target Belgium?” *Guardian*, March 22, 2016. https://www.theguardian.com/world/2016/mar/22/why-was-belgium-targeted-by-bombers.

Burns, Bob. “Inside Look: TSA Layers of Security.” *Transportation Security Administration* (blog), August 1, 2017. https://www.tsa.gov/blog/2017/08/01/inside-look-tsa-layers-security.

Burns, William J., Robin Dillon-Merrill and Richard John. *Dynamic Aviation Risk Management Solution (DARMS): A Proof of Concept Study Examining Analysis of Terrorism Events*. Los Angeles: National Center for Risk and Economic Analysis of Terrorism Events, USC, 2015. http://create.usc.edu/sites/default/files/projects/sow/3044/tsadarmsmauuncertaintyreportmarch27v1.pdf.

Business Dictionary. S.v. “utility theory.” Accessed January 17, 2017. http://www.businessdictionary.com/definition/utility-theory.html.

Cabinet Office. *Preparation and Planning for Emergencies: Responsibilities of Responder Agencies and Others*. London: Cabinet Office, 2013. https://www.gov.uk/guidance/preparation-and-planning-for-emergencies-responsibilities-of-responder-agencies-and-others.

California State Assembly. "Active Shooter LAX Hearing 2-28-14." Accessed December 30, 2017. assembly.ca.gov/sites/assembly.ca.gov/files/Active%20Shooter%20 LAX.pdf.

CBC News. "Brussels Airport Expected to Partially Re-open after Deadly Attack." March 31, 2016. http://www.cbc.ca/news/world/brussels-airport-reopen-belgium-attack-1.3515400.

Chapman Taylor. "Brussels Airport Connector." Accessed November 21, 2017. http:// www.chapmantaylor.com/projects/brussels-airport-connector.

City of Virginia Beach Municipal Center. *Crime Prevention through Environmental Design, General Guidelines for Designing Safer Communities*. Virginia Beach, VA: City of Virginia Beach Municipal Center, 2000. https://www.vbgov.com/ government/departments/planning/areaplans/Documents/Citywide/Cpted.pdf.

Clark, Stephanie. "Interdiction of Terrorist Planning and Surveillance." MSA Security, November 17, 2015. http://www.msasecurity.net/Security-and-Counterterrorism-Blog/Interdiction-of-Terrorist-Planning-and-Surveillance.

CNN. "Federal Grand Jury Indicts LAX Shooting Suspect." December 17, 2013. http:// www.cnn.com/2013/12/17/travel/lax-shooting-indictment//.

Coaffee, Jon, Cerwyn Moore, David Fletcher, and Lee Bosher. "Resilient Design for Community Safety and Terror-Resistant Cities." In *Proceedings of the ICE: Municipal Engineer* 161, no. 2 (2008): 103–110. https://dspace.lboro.ac.uk/ dspace-jspui/handle/2134/9204.

Congress. "Title I—Aviation Security." Accessed August 20, 2017. https://www. congress.gov/bill/107th-congress/senate-bill/1447/text?overview=closed.

Congress.Gov. "H.R.636-FAA Extension, Safety, and Security Act of 2016." Accessed January 20, 2017. https://www.congress.gov/bill/114th-congress/house-bill/636/ text.

Controller of Her Majesty's Stationery Office. *CONTEST: The United Kingdom's Strategy for Countering Terrorism*. London: e Stationery Office Limited, 2011. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/97 995/strategy-contest.pdf.

Cornell Law School. "49 CFR 1542.101 General Requirements." Accessed August 21, 2017. https://www.law.cornell.edu/cfr/text/49/1542.101.

——. 49 CFR Part 1544—Aircraft Operator Security: Air Carriers and Commercial Operators." Legal Information Institute. Accessed August 21, 2017. https://www. law.cornell.edu/cfr/text/49/part-1544.

Cowan, Rod. “Planes, Brains & Auto Mobiles.” *Glasgow Airport, Security Insider* 15, no. 1 (FEB/MAR 2010): 20–28.

Crichton, Gillies. “An Examination of the Glasgow Airport Terrorist Attack on 30 June 2007: Embracing Isomorphic Learning to Manage Risk.” Master’s thesis, University of Leicester, 2013.

——. “Case Study: The Glasgow Airport Attack from a Business Continuity and Crisis Management Point of View.” *Business Continuity Journal* 2, no. 3 (May 20, 2008): 18–24.

——. “Glasgow Airport Terrorist Incident.” *Blueprint, Enhancing the Profession*, no. 50 (Autumn 2007): 1–33.

——. “Learning from History: The Glasgow Airport Terrorist Attack.” *Journal of Business Continuity & Emergency Planning* 8, no. 2 (2014): 169–180.

Crowe, Timothy. *Crime Prevention through Environmental Design, Applications of Architectural Design and Space Management Concepts*. Boston: Butterworth-Heinemann, 2000.

Daily Mail. “NHS Doctor Jailed for 32 Years for Bungled Terror Bomb Plot.” http://www.dailymail.co.uk/news/article-1096822/NHS-doctor-jailed-32-years-bungled-terror-bomb-plot.html.

——. “Terror in the Terminal.” March 23, 2017. http://www.dailymail.co.uk/news/article-3503928/Two-explosions-heard-Brussels-Airport.html.

Dalton, Alastair. “Glasgow Terror Attack Transformed Flying Forever.” The Scotsman, June 30, 2017. https://www.scotsman.com/regions/glasgow-strathclyde/glasgow-terror-attack-transformed-flying-forever-1-4490862.

Deccan Chronicle. “Brussels Airport Bombers Targeted US, Jews: Probe.” January 24, 2017. http://www.deccanchronicle.com/world/europe/240117/brussels-airport-bombers-targeted-us-jews-probe.html.

Demeestere, Matthieu. “Brussels Airport Eyes Sunday Reopening as Govt, Police Agree Security Deal.” *Digital Journal*, April 1, 2016. http://www.digitaljournal.com/news/world/brussels-airport-reopening-nears-as-security-deal-reached-with-police/article/461768.

Department of Transport. *Airport Policing, Funding, and Security Planning, A Consultation Paper*. London: Home Office, 2008. http://library.college.police.uk/docs/dft/airportpolicing-consultationpaper.pdf.

——. *Airport Security Planning Quick Guide*. London: Home Office, 2010. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/11516/guide.pdf.

——. *TRANSEC Annual Report April 2008–March 2009*. London: Department of Transport, 2009. http://webarchive.nationalarchives.gov.uk/+/http:/www.dft.gov.uk/pgr/security/about/transecannualreports/transecannualreport0708.pdf.

Discover Los Angeles. "A Basic Guide to Los Angeles International Airport." Last updated December 14, 2017. https://www.discoverlosangeles.com/blog/basic-guide-los-angeles-international-airport.

EASA. "Legal and Regulatory Framework." Accessed August 21, 2017. https://www.easa.europa.eu/easa-and-you/safety-management/accident-and-incident-investigation-support/legal-and-regulatory-framework.

Elias, Bart. *Airport Passenger Screening: Background and Issues for Congress*. CRS Report No. R40543. Washington, DC: Congressional Research Service, 2009. https://fas.org/sgp/crs/homesec/R40543.pdf.

Elias, Bart, David Randall Peterman, and John Frittelli. *Transportation Security: Issues for the 114th Congress*. CRS Report No. RL33512. Washington, DC: Congressional Research Service, 2016. https://fas.org/sgp/crs/homesec/RL33512.pdf.

Estrada, Mario Arturo Ruiz, and Evangelos Koutronas. "Terrorist Attack Assessment: Paris November 2015 and Brussels 2016." *Journal of Policy Modeling* 38, no. 3 (April 2016): 1–19. http://dx.doi.org/10.1016/j.jpolmod.2016.04.001.

EUR-Lex. "Commission Implementing Regulation (EU) 2015/1998 of 5 November 2015 Laying down Detailed Measures for the Implementation of the Common Basic Standards on Aviation Security (Text with EEA Relevance)." November 14, 2015. http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32015R1998.

——. "Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee of the Regions, Action Plan to Support the Protection of Public Spaces." October 18, 2017. http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1510624293824&uri=CELEX:52017DC0612.

European Aviation Safety Agency. "Regulation (EC) No 216/2008." 2008. https://www.easa.europa.eu/document-library/regulations/regulation-ec-no-2162008.

European Commission. "Migration and Home Affairs, Schengen Area." Last updated December 20, 2017. https://ec.europa.eu/home-affairs/what-we-do/policies/borders-and-visas/schengen_en.

European Commission Mobility and Transport. "Air, Aviation Security." December 30, 2017. https://ec.europa.eu/transport/modes/air/security_en.

Expat Club. "Brussels Airport Tour." 2017. https://expatclub.org/event/coudenberg-2/.

Fagel, Michael J., and Jennifer Hesterman. *Soft Targets and Crisis Management*. Boca Raton, FL: Taylor & Francis Group, 2017.

Fagel, Michael J., and S. Shane Stovall. "Soft Target Planning." In *Soft Targets and Crisis Management*, edited by Michael J. Fagel and Jennifer Hesterman, 391–402. Boca Raton, FL: CRC Press Taylor & Francis Group, 2017.

Farberov, Snejana. "LAX Gunman Planned to Die in Shoot-out With 'Pigs and the TSA' Who He Ranted About in Suicide Note He Took on Deadly Rampage." *Daily Mail*, November 2, 2013. http://www.dailymail.co.uk/news/article-2483833/LAX-airport-shooter-Paul-Anthony-Ciancia-ranted-killing-pigs-TSA-pictured.html.

Federal Aviation Administration. *The Economic Impact of Civil Aviation on the U.S. Economy*. Washington, DC: Federal Aviation Administration, 2016. https://www.faa.gov/air_traffic/publications/media/2016-economic-impact-report_FINAL.pdf.

Federal Public Service Mobility and Transport, Belgian Civil Aviation Authority. *Belgium Aviation Safety Programme*. Brussels: Belgian Civil Aviation Authority, 2015. https://mobilit.belgium.be/sites/default/files/downloads/Belgium%20Aviation%20Safety%20Programme_v1.0.pdf.

Fennelly, Lawrence, and Timothy Crowe. *Crime Prevention through Environmental Design*. Amsterdam: Elsevier Science, 2013. ProQuest Ebook Central. https://ebookcentral.proquest.com/lib/ebook-nps/detail.action?docID=1222590.

Fletcher, Ken. "Aviation Security: A Case for Risk-Based Passenger Screening." Master's thesis, Naval Postgraduate School, 2011.

Fox News. "LAX Shooting Suspect Reportedly Told Police He Acted Alone." November 4, 2013. http://www.foxnews.com/us/2013/11/04/lax-shooting-suspect-reportedly-told-police-acted-alone.html.

Frey, Bruno S., and Simon Luechinger. "How to Fight Terrorism: Alternatives to Deterrence." *Institute for Empirical Research in Economics* 14, no. 4 (2003): 237–249.

——. *How to Fight Terrorism: Alternatives to Deterrence*. Zurich: University of Zurich, 2002.

Gamma 2 Robotics. "Meet the New Face of Security." 2017. http://www.gamma2robotics.com.

Gersema, Emily. "Attack on an Airline or Airport Could Cost the Economy Billions in Losses." USC News, February 9, 2017. https://news.usc.edu/116174/attack-on-an-airline-or-airport-could-cost-the-economy-billions-in-losses/.

Glasgow Airport. “About Us.” Accessed November 22, 2017. https://www.glasgowairport.com/corporate/about-us/.

——. “Destination Inspiration.” Accessed November 23, 2017. https://www.glasgowairport.com/destination-inspiration/.

——. “Flight Guide, Winter 17/18 & Summer 18.” Accessed November 23, 2017. https://www.glasgowairport.com/destination-inspiration/route-map/.

——. “Glasgow Airport’s New Road Layout.” YouTube video, 1:12, March 15, 2017. https://www.youtube.com/watch?v=SyNkOlK8JDo.

——. “Info, Airport Maps.” Accessed November 21, 2017. https://www.glasgowairport.com/im-picking-up-dropping-off/info/.

——. “Info, Meeting Someone?” Accessed November 21, 2017. https://www.glasgowairport.com/im-picking-up-dropping-off/info/.

——. “Master Plan, Our Vision, Glasgow Airport Draft Master Plan 2011.” Accessed November 22, 2017. https://www.glasgowairport.com/corporate/about-us/.

——. “Media Centre.” January 2018. https://www.glasgowairport.com/media-centre/a-record-99-million-passengers-make-2017-glasgow-airports-best-ever-year/.

——. “Parking at Glasgow Airport.” Accessed November 23, 2017. https://www.glasgowairport.com/im-departing/parking/.

——. “Pick-up and Drop-off.” Accessed November 23, 2017. https://www.glasgowairport.com/im-picking-up-dropping-off/pick-up-and-drop-off/.

Goel, Manmohan Dass, and Vasant A. Matsagar. “Blast-Resistant Design of Structures.” *Practice Periodical on Structural Design and Construction* 19, no. 2 (2014): 04014007-1–04014007-9. doi: 10.1061/(ASCE)SC.1943-5576.0000188.

Gov.UK. “Protecting Crowded Places from Terrorism.” November 14, 2014. https://www.gov.uk/government/collections/crowded-places.

GovTrack. “S. 1447 (107th): Aviation and Transportation Security Act.” Accessed August 20, 2017. https://www.govtrack.us/congress/bills/107/s1447/text.

Grad, Shelby, and Richard Winton. “Before Brussels, LAX Was Repeatedly a Target of Terrorism.” *Los Angeles Times*, March 22, 2016. http://www.latimes.com/local/lanow/la-me-ln-before-brussels-lax-was-target-of-terrorism-20160322-story.html.

Grant, Matthew, and Mark G. Stewart. "Benefit of Distributed Security Queuing for Reducing Risks Associated with Improvised Explosive Device Attacks in Airport Terminals." *ASME J. Risk Uncertainty Part B* 3, no. 2 (2017): 021003–021003-9. doi: 10.1115/1.4035730.

Gregory, Frank. "Chapter 6: National Governance Structures to Manage the Response to Terrorist Threats and Attacks; A Cross-national Comparative Analysis with Special Reference to the UK 'Lead Department' Response Structure and UK Counter-terrorism Strategy." In *Homeland Security in the UK, Future Preparedness for Terrorist Attack Since 9/11*, edited by Paul Wilkinson, 118–142. New York: Routledge, 2007.

Gross, Doug. "Sources: Alleged Shooter Hated Government, 'New World Order'." CNN, November 3, 2013. https://www.cnn.com/2013/11/01/us/lax-shootings-suspect/index.html.

Grover, Jennifer. *Homeland Security and Justice: Explosives Detection Canines, TSA Has Enhanced Its Canine Program, but Opportunities May Exist to Reduce Costs*. GAO-16-444T. Washington, DC: Government Accountability Office, 2016. www.gao.gov/assets/660/651725.pdf.

Guimerá, R., and L.A.N. Amaral. "Modeling the World-Wide Airport Network." *European Physical Journal B.* 38, no. 2 (2004): 381–385. https://doi.org/10.1140/epjb/e2004-00131-0.

Habash, George. "Appendix A, Terrorist Planning Cycle." In *A Military Guide to Terrorism in the Twenty-First Century, Appendix A, Terrorist Planning Cycle, U.S. Army Training and Doctrine Command DCSINT Handbook No. 1*. Fort Leavenworth, KS: U.S. Army Training and Doctrine Command, 2007. https://fas.org/irp/threat/terrorism/guide.pdf.

Hamilton, Matt. "LAX Shooter's Plea Agreement Reveals He Did Not Consider Himself a Terrorist, but a 'Patriot'." *Los Angeles Times*, September 1, 2016. http://www.latimes.com/local/lanow/la-me-ln-lax-shooter-guilty-plea-20160901-snap-story.html.

HEALD. "What is PAS 68?" Accessed January 11, 2018. https://www.heald.uk.com/what-is-pas-68/.

Hesterman, Jennifer. *Soft Target Hardening, Protecting People from Attack*. Boca Raton, FL: CRC Press, 2015.

Hollingshead, Todd. "BYU Engineers Built a Bulletproof Origami Shield to Protect Law Enforcement." *Intellect*, February 16, 2017. https://news.byu.edu/news/byu-researchers-built-bullet-proof-origami-shield-protect-law-enforcement.

Home Office. *Protecting Crowded Places: Design and Technical Issues*. London: Home Office, 2014. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/302016/DesignTechnicalIssues2014.pdf.

Hope, Alan. "Brussels Airport Temporary Check-ins Working Smoothly." *The Bulletin*, April 5, 2016. http://www.xpats.com/brussels-airport-temporary-check-ins-working-smoothly.

IATA. *The Impact of "BREXIT" on UK Air Transport*. Montreal, Canada: IATA, 2016. http://www.iata.org/publications/economic-briefings/impact-of-brexit.pdf.

ICAO. "About ICAO." Accessed August 21, 2017. https://www.icao.int/about-icao/Pages/default.aspx.

——. "Thirteenth Symposium on the ICAO Traveller Identification Programme." October 24–26, 2017. https://www.icao.int/Meetings/TRIP-Symposium-2017/Presentations/SEESMAA.pdf#search=soft%20targets.

iFly. "Glasgow (GLA) Airport Terminal Map." Accessed November 23, 2017. http://www.ifly.com/glasgow-airport/terminal-map.

iHLS. "Vehicle Ramming Attacks: Are There Any Security Measures?." January 9, 2017. https://i-hls.com/archives/74006.

Illusion Works, LLC. "Ames Room." 1997. http://psylux.psych.tu-dresden.de/i1/kaw/diverses%20Material/www.illusionworks.com/html/ames_room.html.

Institutes for Economics and Peace. "Global Terrorism Index 2015." November 2015. http://www.visionofhumanity.org/reports/page/2/.

Jackson, Brian A., Tom LaTourrette, Ed Chan, Russell, Lundberg, Andrew R. Morral, and David R. Frelinger. *Efficient Aviation Security: Strengthening the Analytic Foundation for Making Air Transportation Security Decisions*. Santa Monica, CA: RAND, 2012.

Jambon, Jan. "Deputy Prime Minister and Minister of Security and Home Affairs." Accessed August 21, 2017. http://jambon.belgium.be/en/.

Jankovec, Oliver. "ACI Europe Letter 28 April 2016 to Prime Minister Dmitry Medvedev Landside Security Measures." ACI Europe, April 27, 2016. https://www.aci-europe.org/policy/position-papers.html?view=group&group=1&id=4.

Jervis, Robert, Richard Ned Lebow, and Janice Gross Stein. *Psychology and Deterrence*. Baltimore, MD: Johns Hopkins University Press, 1985.

Johnstone, William. “Passenger Aviation Security Layers.” *Elsevier SciTech Connect*, October 6, 2015. http://scitechconnect.elsevier.com/passenger-aviation-security-layers/.

Jones, Seth G. *Hunting in the Shadows, The Pursuit of Al Qa’ida since 9/11*. New York: W.W. Norton & Company, Inc., 2012.

Journal. “LAX Gunman Charged, Carried Note Saying He Planned to Kill ‘Multiple’ Agents.” November 3, 2013. http://www.thejournal.ie/lax-shooting-gunman-charged-tsa-agent-1158539-Nov2013/.

Kalvach, Zdeněk. *Basics of Soft Targets Protection Guidelines*. Prague: Soft Targets Protection Institute, 2016. www.mvcr.cz/cthh/soubor/basics-of-soft-target-protection-guidelines.aspx.

Kalwall. “Project Reports.” Accessed January 17, 2017. https://www.kalwall.com/product-brochures/project-reports/.

——. “Technology.” Accessed January 17, 2017. https://www.kalwall.com/technology/.

Kaustubh. “KK Travails.” *Myblogkaustubh* (blog), March 22, 2016. https://myblogkaustubh.wordpress.com/2016/04/22/kk-travails/.

Knightscope Incorporated. “Services.” Accessed January 18, 2017. https://www.knightscope.com/services/.

Kostiner, Kevin. “Glasgow Airport’s Security Improved after Terror Attack.” Copybook, November 9, 2009. https://www.copybook.com/news/glasgow-airports-security-improved-after-terror-attack.

Kroenig, Matthew, and Barry Pavel. “How to Deter Terrorism.” *The Washington Quarterly* 35, no. 2 (2012): 21–36. doi: 10.1080/0163660X.2012.665339.

LAX Airport Parking Lot. “LAX Map and Gate Information.” 2018. http://www.laxairportparkinglot.com/lax-parking-airport-information/.

Lebow, Richard Ned, and Janice Gross Stein, ed. *Psychology and Deterrence*. Baltimore, MD: Johns Hopkins University Press, 1985.

Leone, Geraline K., and Sanchoy Das. “Operating Characteristics of Passenger Screening Processes and the Development of a Paced Inspection System.” Executive Committee for the Interdisciplinary Program in Transportation. New Jersey Institute of Technology’s Electronic Thesis & Dissertations Project, January 2010. https://www.researchgate.net/publication/281655949_Operating_characteristics_of_passenger_screening_processes_and_the_development_of_a_paced_inspection_system.

Levine, David. "Economic and Game Theory, What is Game Theory." University of California, Los Angeles. Accessed November 21, 2016. http://levine.sscnet.ucla.edu/general/whatis.htm.

Los Angeles County Economic Development Corporation. "Study Shows Significant Positive Economic Impacts of LAX Projects and Operations." April 21, 2016. https://laedc.org/2016/04/21/study-shows-positive-economic-impacts-lax-projects-and-operations/.

Los Angeles Daily News. "Defense Indicates Mental Issues May Be Raised at Trial of LAX Shooter." August 28, 2017. https://www.dailynews.com/2015/02/10/defense-indicates-mental-issues-may-be-raised-at-trial-of-lax-shooter/.

Los Angeles Times. "Federal Criminal Complaint against Paul Anthony Ciancia." November 2, 2013. http://documents.latimes.com/federal-criminal-complaint-ciancia/.

Los Angeles World Airports. *Active Shooter Incident and Resulting Airport Disruption, A Review of Response Operations*. Los Angeles: Los Angeles World Airport, 2014. http://www.activeshootertest.com/wp-content/uploads/2015/07/LAWA-T3-After-Action-Report-March-18-2014.pdf.

——. "About Los Angeles World Airports." October 2015. http://www.lawa.org/welcome_LAWA.aspx?id=684.

——. "Active Shooter Incident and Airport Disruption, After Action Review." March 18, 2014. lawa.granicus.com/MetaViewer.php?view_id=4&clip_id=156&meta_id=15757.

——. "Anticipated Process and Schedule." 2014. http://www.connectinglax.com/process.html.

——. *Airport Structural Design Standards*. Los Angeles: Los Angeles World Airports, 2017. http://www.lawa.org/uploadedFiles/LAXDev/DCH/2017/Design_Stds/Airport%20Structural%20Design%20Standards%20July%202017.pdf.

——. "Dining & Shopping." 2017. https://www.flylax.com/lax-dining-and-shopping.

——. "LAX Flyaway." 2017. https://www.flylax.com/flyaway.

——. "Smart Traveler Tips—English." November 2015. https://www.flylax.com/lax-guides-tips-and-amenities.

——. "Sustainability Report." 2016. http://www.laxsustainability.org/documents/Sustainability_Report_2016.pdf.

——. “The Solution.” 2014. https://www.lawa.org/en/lawa-landside-access-modern ization-program/solution.

Lundberg, Russell, and Henry Willis. “Assessing Homeland Security Risks: A Comparative Assessment of Ten Hazards.” *Homeland Security Affairs* 11, art. 10 (December 2015). https://www.hsaj.org/articles/7707.

Magnusson, Ari. “Brussels Airport Departure Terminal Reopens: Is Heightened Security the New Normal?” Apex, May 3, 2016. https://apex.aero/2016/05/03/brussels-airport-departure-terminal-reopens-is-heightened-security-new-normal.

Mapio.net. “JFK, Terminal 1, Inside, Departure Gates.” Accessed February 17, 2018. http://mapio.net/pic/p-47637672/.

Mather, Kate, Matt Stevens, and Ashley Powers. “LAX Shooting: Gunman Wanted to Kill Several TSA Agents, Complaint Says.” *Los Angeles Times*, November 3, 2013. http://www.latimes.com/local/lanow/la-me-ln-lax-shooting-gunman-kill-tsa-agents-20131103-story.html.

Michallon, Clemence, Emily Crane, Ashley Collman, Liam Quinn, and Jose Lambiet. “Revealed: FBI RETURNED Ft. Lauderdale Shooter’s Gun a Month before Airport Attack after He Reported Himself because He Thought the CIA was Making Him Fight for ISIS.” *Daily Mail*, January 7, 2017. http://www.dailymail. co.uk/news/article-4097416/Gunman-picked-passengers-sent-crowds-fleeing-airport.html.

Morral, Andrew, and Brian A. Jackson. *Understanding the Role of Deterrence in Counterterrorism Security*. Santa Monica, CA: RAND, 2009. http://www.rand. org/pubs/occasional_papers/OP281.html.

Morral, Andrew R., Carter C. Price, David S. Ortiz, Bradley Wilson, Tom LaTourrette, Blake W. Mobley, Shawn McKay, and Henry H. Willis. *Modeling Terrorism Risk to the Air Transportation System: An Independent Assessment of TSA's Risk Management Analysis Tool and Associated Methods*. Santa Monica, CA: RAND, 2012. https://www.rand.org/content/dam/rand/pubs/monographs/2012/RAND_ MG1241.pdf.

Mullin, Gemma. “Brussels Attacks: First CCTV from Inside Packed airport Terminal Shows Travellers Seconds before Twin Explosions.” *Irish Mirror*, March 25, 2016. http://www.irishmirror.ie/news/world-news/brussels-attacks-first-cctv-inside-7621061.

National Academies of Sciences, Engineering, and Medicine. *Airport Passenger Terminal Planning and Design, Volume 1: Guidebook*. Washington, DC: National Academies Press, 2010. https://www.nap.edu/download/22964.

National Commission of Terrorist Attacks upon the United States. *The 9/11 Commission Report: Final Report of the National Commission of Terrorist Attacks upon the United States*. New York: W. W. Norton, 2004.

National Consortium for the Study of Terrorism and Responses to Terrorism. *Fact Sheet—Armed Assault at Los Angeles International Airport (LAX)*. College Park, MD: University of Maryland, 2013. start.umd.edu/pubs/STARTFactSheet_ArmedAssaultatLAX_Nov2013.pdf.

National Planning Framework 3 Action Programme. "10 Strategic Airport Enhancements." Accessed November 28, 2017. https://npfactionprogramme.com/national-developments/10-strategic-airport-enhancements/.

National Safe Skies Alliance, Inc. "Recommended Security Guidelines for Airport Planning, Design, and Construction." April 2017. http://www.transecure.us/recommended-security-guidelines-for-airport-planning-design-and-construction/.

National Science and Technology Council-Domestic Improvised Explosive Devices Subcommittee. *Research Challenges in Combating Terrorist Use of Explosives in the United States*. Washington, DC: National Science and Technology Council-Domestic Improvised Explosive Devices Subcommittee, 2008. http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA505299.

NBC News. "Photos Show Damage inside Brussels Airport after Attack." March 30, 2017. https://www.nbcnews.com/storyline/brussels-attacks/photos-show-damage-inside-brussels-airport-after-attack-n548071.

New York Times. "What Happened at Each Location in the Brussels Attacks." March 22, 2016. https://www.nytimes.com/interactive/2016/03/22/world/europe/brussels-attacks-graphic.html.

O'Hare, Paul. "The Day Terror Came to Scotland—The Glasgow Airport Attack 10 Years On." Daily Record, June 27, 2017. http://www.dailyrecord.co.uk/news/scottish-news/day-terror-came-scotland-glasgow-10693742.

Paddock, Catharine. "Glasgow Airport Train-train Link to Boost Local Economy." *Market Business News*, November 27, 2016. http://marketbusinessnews.com/glasgow-airport-tram-train-link-boost-local-economy/148877.

PBS. "Ahmed Ressam's Millennium Plot." Accessed January 12, 2017. https://www.pbs.org/wgbh/pages/frontline/shows/trail/inside/cron.html.

Politco. "Brussels Attacks: Updates." March 30, 2016. http://www.politico.eu/article/brussels-attacks-live-blog-isil-terror-2016-malbeek-zaventem/.

Prevatt, Juliana S. “Crime Prevention through Environmental Design (CPTED) and the Role of Facilities Planning in Force Protection.” Master’s thesis, Graduate School of the University of Florida, 1998.

Price, Jeffrey C., and Jeffrey S. Forrest. *Practical Aviation Security, Predicting and Preventing Future Threats*. Burlington, MA: Elsevier, 2009.

Riedman, David. “The Cold War on Terrorism: Reevaluation Critical Infrastructure Facilities as Targets for Terror Attacks.” *Homeland Security Affairs* 13, art. 3 (June 2017): 1–24. https://www.hsaj.org/articles/13976.

Rivalcoba, Ivan, Oriam de Gyves, Issac Rudomin, and Nuria Pelechano. “Simulated Virtual Crowds Coupled with Camera-Tracked Humans.” In *Computer Vision, Imaging and Computer Graphics—Theory and Applications*, *Communications in Computer and Information Science*, vol. 550, 62–77. Chanm, Switzerland: Springer, Cham, 2015. doi: 10.1007/978-3-319-25117-2_5.

Robot Security Systems. “Robot Security Systems 24/7 Safety and Security.” 2016. http://www.robotsecuritysystems.com/.

Sakip, Siti Rasidah Md, Noraini Johari, and Mohd Najib Mohd Salleh. “The Relationship between Crime Prevention through Environmental Design and Fear of Crime.” *Procedia- Social Sciences* 68 (2012): 628–636. doi: 10.1016/j.sbspro.2012.12.254.

Sandlar, Todd, and Daniel G. Arce M. “Terrorism and Game Theory.” *Forthcoming Simulation & Gaming* 34, no. 3 (September 2003). www.utdallas.edu/~tms06 3000/website/Terror_Games.pdf.

Saville, Gregory. “ATRiM for Critical Infrastructure Protection.” In *Randal Atlas, 21st Century Security and CPTED, Designing for Critical Infrastructure Protection*, edited by Randall I. Atlas, 289–299. 2nd ed. New York: CRC Press, Taylor & Francis Group, 2013.

Schiller, Ben. “Meet the Scary Little Security Robot That’s Patrolling Silicon Valley.” *Fast Company*, August 13, 2015. https://www.fastcoexist.com/3049708/meet-the-scary-little-security-robot-thats-patrolling-silicon-valley.

SCN Corporate Connect. “CEO Interview-Knightscope, Inc.” YouTube Video, 7:18. January 28, 2017. https://www.youtube.com/watch?v=fjJPH3jzfVE.

Seidenstat, Paul, and Francis X. Splane. *Protecting Airline Passengers in the Age of Terrorism*. Santa Barbara, CA: ABC-CLIO, 2009.

Shapiro, Emily, Julia Jacobo, and David Caplan. "Veteran Allegedly Kills 5 at Fort Lauderdale Airport Shooting, Terrorism Not Ruled Out." ABC News, January 7, 2017. http://abcnews.go.com/US/shooter-custody-incident-fort-lauderdale-airport-injuries-reported/story?id=44602546.

Sharkov, Damien. "Brussels Attacks to Cost Belgium $4.47 Billion." *Newsweek*, March 23, 2016. http://www.newsweek.com/brussels-attacks-cost-belgium-4-billion-euros-440013.

Sheppard, Ben. "Mitigating Terror and Avoidance Behavior through Risk Perception Matrix to Augment Resilience." *Journal of Homeland Security and Emergency Management* 8, no. 1 (2011): 1–19. doi: 10.2202/1547-7355.1840.

Smith, Joseph L., and Daniel R. Renfroe. "Active Shooter: Is There a Role for Protective Design?." Applied Research Associates, Inc., August 2, 2016. https://www.wbdg.org/resources/active-shooter-there-role-protective-design.

Stevens, Donald, Terry Schell, Thomas Hamilton, Richard Mesic, and Michael S. Brown. *Near-Term Options for Improving Security at Los Angeles International Airport*. Santa Barbara, CA: RAND, 2004. www.rand.org/content/dam/rand/pubs/documented.../2004/RAND_DB468-1.pdf.

Stewart, Mark G., and John Mueller. *Risk-Based Passenger Screening: Risk and Economic Assessment of TSA PreCheck Increased Security at Reduced Cost?* Callaghan, Australia: University of Newcastle, Center for Infrastructure Performance and Reliability, 2016. http://hdl.handle.net/1959.13/1313869.

Stewart, Scott. "The Evolution of Airport Attacks." Security Management, April 1, 2017. https://sm.asisonline.org/Pages/The-Evolution-of-Airport-Attacks.aspx.

Stoelker, Tom. "Zahner, Zaha's Schumacher, CASE, and More: Facades Conference 2012." *Architect's Newspaper*, February 16, 2012. https://archpaper.com/2012/02/live-blogging-collaboration-facades-conference/.

Structura Curtainwall Engineering. "About Kalwall." 2012. http://www.structura-uk.com/kalwall/KAL_About_Kalwall.php.

——. "Blast Resistant-Transport." 2012. http://www.structura-uk.com/kalwall/KAL_Blast_Trans_GLA.php.

——. "Research and Development Plant." 2012. http://www.structura-uk.com/kalwall/KAL_Explo_Ind_JAN.php.

Tan, Eugene E. Guang. *Checkpoint or Chokepoint: Aviation Security Lessons from Istanbul and Brussels*. RSIS Commentaries, No. 184. Singapore: Nanyang Technological University, 2016. http://hdl.handle.net/10220/41019.

Tata, Samantha, and Kim Baldonado. "Alleged LAX Gunman Spoke of Suicide Before Shooting." NBC Southern California, November 2, 2013. https://www.nbclosangeles.com/news/local/Paul-Anthony-Ciancia-LAX-Shooting-Suspect-Los-Angeles-Airport-TSA-230289841.html.

Thaler, Richard H., and Cass R. Sunstein. *Nudge: Improving Decisions about Health, Wealth, and Happiness*. New York: Penguin Books, 2009.

Theodoridis, Theodoros, and Huosheng Hu. "Toward Intelligent Security Robots: A Survey." *IEEE Transactions on Systems, Man, and Cybernetics—Part C: Applications and Reviews* 42, no. 6 (2012): 1219–1230. doi: 10.1109/TSMCC.2012.21.2198055.

Thompson, Ria. "Visual Illusions: The Muller-Lyer Illusion." Prezi, December 7, 2015. https://prezi.com/sm1r7yoij6em/visual-illusions-the-muller-lyer-illusion/.

Tomlinson, Simon, Martin Robinson, Julian Robinson, John Stevens, and Mark Duell. "Terror in the Terminal: Chilling Footage Shows Moment Passengers Cower under Desks and Run for Their Lives in Immediate aftermath of Twin Blasts." *Daily Mail*, March 22, 2016. www.dailymail.co.uk/news/article.../Two-explosions-heard-Brussels-Airport.html.

Trager, Robert F., and Dessislava P. Zagorcheva. "Deterring Terrorism, It Can Be Done." *International Security* 30, no. 3 (Winter 2005/2006): 87–123. doi: 10.1162/isec.2005.30.3.87.

Transportation Administration Agency. "Media, Press Releases." January 21, 2016. https://www.tsa.gov/news/releases/2016/01/21/tsa-releases-2015-statistics.

Transportation Security Administration. "Exercise Information System." December 5, 2016. https://www.tsa.gov/for-industry/exercise-information-system.

——. "Factsheets." Accessed May 1, 2017. https://www.tsa.gov/press/factsheets.

——. "Intermodal Security Training and Exercise Program." December 2, 2016. https://www.tsa.gov/for-industry/intermodal-security-training-and-exercise-program.

——. "Public Area Security Summits." May 2017. https://www.tsa.gov/for-industry/public-area-security-summits.

——. "Screening Partnership Program." Accessed February 12, 2018. https://www.tsa.gov/for-industry/screening-partnerships.

——. *Security Guidelines for General Aviation Airport Operators and Users*, Information Publication A-001, Version 2. Washington, DC: Transportation Security Administration, 2017. https://www.tsa.gov/sites/default/files/2017_ga_security_guidelines.pdf.

——. “Transportation Security Timeline.” Accessed August 20, 2017. https://www.tsa.gov/timeline.

——. “TSA’s Successes and Challenges of Risk-Based Security.” https://www.tsa.gov/news/testimony/2012/03/26/tsas-successes-and-challenges-risk-based-security.

Tromp, Nynke, Paul Hekkert, and Peter-Paul Verbeek. “Design for Socially Responsible Behavior: A Classification of Influence Based on Intended User Experience Design Issues.” *Massachusetts Institute of Technology Design Issues* 27, no. 3 (2011): 3–19. doi: 10.1162/DESI_a_00087.

TSA. *TSA Canine Training Center Factsheet*. Washington, DC: TSA, n.d. Accessed May 1, 2017. https://www.tsa.gov/sites/default/files/resources/caninetrainingcenter_factsheet_0.pdf.

U.S. Congress. House of Representatives. *Statement of John Roth, Inspector General, Department of Homeland Security before the Committee on Oversight and Government Reform U.S. House of Representatives Concerning TSA: Security Gaps*. 115th Cong., 2015. https://oversight.house.gov/wp-content/uploads/2015/11/11-3-2015-Committee-Hearing-on-TSA-Roth-DHS-OIG-Testimony.pdf.

——. *Statement of Peter Neffenger, Administrator, Transportation Security Administration U.S. Department of Homeland Security before the United States House of Representatives Committee on Oversight and Government Reform*. 115th Cong., 2015. https://oversight.house.gov/wp-content/uploads/2015/11/11-3-2015-Committee-Hearing-on-TSA-Neffenger-TSA-Testimony.pdf.

U.S. Department of Homeland Security. *2014 Quadrennial Homeland Security Review*. Washington, DC: Department of Homeland Security, 2014. https://www.dhs.gov/sites/default/files/publications/qhsr/2014-QHSR.pdf.

——. Office of Infrastructure Protection.” Accessed August 24, 2017. https://www.dhs.gov/office-infrastructure-protection.

——. *Risk Steering Committee, DHS Risk Lexicon*. Washington, DC: U.S. Department of Homeland Security, 2010. https://www.dhs.gov/sites/default/files/publications/dhs-risk-lexicon-2010_0.pdf.

——. “Transportation Security Overview, Improving Security through Layered, Risk Based Approach.” September 10, 2015. https://www.dhs.gov/transportation-security-overview.

U.S. Department of Justice. “California Man Pleads Guilty in 2013 Shooting Spree at Los Angeles International Airport and Admits to First-Degree Murder of Transportation Security Administration Officer.” Press release, September 6, 2016. https://www.justice.gov/opa/pr/california-man-pleads-guilty-2013-shooting-spree-los-angeles-international-airport-and-admits.

U.S. Department of Transportation, Bureau of Transportation Statistics. "Passenger Travel Facts and Figures; Chapter 2: Passenger Travel." Accessed November 20, 2016. http://www.rita.dot.gov/bts/publications/passenger_travel_2016/chapter2. Enplanement is defined as the number of passengers that board a plane.

U.S. District Court for the Central District of California. *Plea Agreement for Defendant Paul Anthony Ciancia*. No. CR 13-902-PSG. Los Angeles: U.S. District Court for the Central District of California, 2016. www.courthousenews.com/2016/09/06/LAX.pdf.

U.S. Government Accountability Office. *Aviation Security: Airport Perimeter and Access Control Security Would Benefit from Risk Assessment and Strategy Updates*. GAO-16-632. Washington, DC: U.S. Government Accountability Office, 2016. https://www.gao.gov/products/GAO-16-632.

——. *Transportation Security Information Sharing: Results of GAO's Survey of Stakeholder Satisfaction with TSA Products and Mechanisms*. GAO-12-67SP. Washington, DC: U.S. Government Accountability Office, 2012. http://www.gao.gov/special.pubs/gao-12-67sp/.

U.S. Government Publishing Office. "Public Law 107-71 Aviation and Transportation Security Act." Accessed August 21, 2017. https://www.gpo.gov/fdsys/pkg/PLAW-107publ71/content-detail.html.

UPI. "'Taste' of Fear Sought for Britain." November 13, 2008. https://www.upi.com/Top_News/2008/11/13/Taste-of-fear-sought-for-Britain/48731226604016/.

Verstegen, Ian. *Cognitive Iconology, When and How Psychology Explains Images*. Amsterdam: Rodopi, 2014. http://www.brill.com/products/book/cognitive-iconology#BIONOTE_1. https://books.google.com/books?id=Rr32oAEACAAJ&dq=isbn:9789042038240&hl=en&sa=X&ved=0ahUKEwi6v6btgrHYAhXqjFQKHbwjD_YQ6AEIKTAA.

Wasson, Jesse, and Christopher Bluesteen. "Cognitive Defense; Influencing the Target Choices of Less Sophisticated Threat Actors." *Homeland Security Affairs* 13, no. 1 (2017): 1–17. https://www.hsdl.org/?view&did=800157.

Watson, Jim. "Better Layouts for Queue Lines." Accessed January 27, 2017. http://www.jamesrobertwatson.com/quelines.html.

WeArePopUp. "Experiential Space @ Glasgow Airport." Accessed December 9, 2017. https://wearepopup.com/u/brand-promotion-site-gl/.

Wheeler, John. *Airport Security Report*. United Kingdom: Home Office, 2002. http://webarchive.nationalarchives.gov.uk/+/http:/www.dft.gov.uk/pgr/security/aviation/airport/airportsecurityreport.pdf.

White House. *Combating Terrorist Use of Explosives in the United States, Homeland Security Presidential Directive 19*. Washington, DC: White House, 2007. https://fas.org/irp/offdocs/nspd/hspd-19.pdf.

Wikipedia. S.v. "2007 Glasgow airport attack." Last updated January 29, 2018. https://en.wikipedia.org/wiki/2007_Glasgow_Airport_attack#cite_note-MSNBC-1.

——. "2016 Brussels bombing." Last updated December 9, 2017. https://en.wikipedia.org/wiki/2016_Brussels_bombings.

——. "AGS airports." Accessed November 22, 2017. https://en.wikipedia.org/wiki/AGS_Airports.

——. "Brussels airport." November 17, 2017. https://en.wikipedia.org/wiki/Brussels_Airport.

——. "federal public service mobility and transport." Last edited January 20, 2018. https://en.wikipedia.org/wiki/Federal_Public_Service_Mobility_and_Transport.

——. "Glasgow airport." Last updated February 28, 2018. https://en.wikipedia.org/wiki/Glasgow_Airport#cite_note-40.

——. "Los Angeles international airport." Accessed December 12, 2017. https://en.wikipedia.org/wiki/Los_Angeles_International_Airport.

——. "Pan Am flight 103." Last updated January 31, 2008. https://en.wikipedia.org/wiki/Pan_Am_Flight_103.

World Bank. "GDP (current US$)." Accessed February 17, 2018. https://data.worldbank.org/indicator/NY.GDP.MKTP.CD.

Yahoo and Agencies. "'You're Going to Have to Shoot Me' Man Says before Launching at Cop in US Airport." June 12, 2016. https://au.news.yahoo.com/world/a/31819778/youre-going-to-have-to-shoot-me-man-says-before-launching-at-cop-at-us-airport/.

Yin, Robert. *Case Studies Research, Design, and Methods*. London: Sage, 2003.

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