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THESIS

**YIELD TO PEDESTRIANS?
EXAMINING INFRASTRUCTURE AND
DEFENSIVE-MINDED METHODOLOGIES IN SECURING
PEDESTRIAN-RICH ENVIRONMENTS**

by

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March 2023

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Urban municipalities feature pedestrian-rich environments with limited mitigation measures to prevent vehicle-caused pedestrian fatalities. Limited pedestrian protections represent an attractive target for nefarious actors to commit vehicle ramming attacks (VRA). There are defensive-minded methodologies that afford greater mitigation against deadly vehicle-versus-pedestrian collisions and VRAs in urban pedestrian-rich environments. This thesis examines the vulnerability of pedestrian-rich environments to vehicle-caused pedestrian fatalities and provide recommendations for stakeholders to better secure the environments. It also examines both the target hardening and protective security methodologies using a theoretical analysis model. By analyzing these defensive-minded methodologies, this thesis explores a homogenous framework for securing urban pedestrian-rich environments: the target hardening/protective security spectrum (THPSS). This thesis concludes with recommendations for urban municipalities to implement to better protect their respective pedestrian-rich environments from deadly vehicle-versus-pedestrian collisions and VRAs. This thesis provides recommendations to better secure outdoor dining establishments, street fairs, road races, and urban public parks from vehicle-caused fatalities.

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YIELD TO PEDESTRIANS? EXAMINING INFRASTRUCTURE AND DEFENSIVE-MINDED METHODOLOGIES IN SECURING PEDESTRIAN-RICH ENVIRONMENTS

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ABSTRACT

Urban municipalities feature pedestrian-rich environments with limited mitigation measures to prevent vehicle-caused pedestrian fatalities. Limited pedestrian protections represent an attractive target for nefarious actors to commit vehicle ramming attacks (VRA). There are defensive-minded methodologies that afford greater mitigation against deadly vehicle-versus-pedestrian collisions and VRAs in urban pedestrian-rich environments. This thesis examines the vulnerability of pedestrian-rich environments to vehicle-caused pedestrian fatalities and provide recommendations for stakeholders to better secure the environments. It also examines both the target hardening and protective security methodologies using a theoretical analysis model. By analyzing these defensive-minded methodologies, this thesis explores a homogenous framework for securing urban pedestrian-rich environments: the target hardening/protective security spectrum (THPSS). This thesis concludes with recommendations for urban municipalities to implement to better protect their respective pedestrian-rich environments from deadly vehicle-versus-pedestrian collisions and VRAs. This thesis provides recommendations to better secure outdoor dining establishments, street fairs, road races, and urban public parks from vehicle-caused fatalities.

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LIST OF ACRONYMS AND ABBREVIATIONS

CISA	Cybersecurity and Infrastructure Security Administration
CPNI	Centre for the Protection of National Infrastructure
CTB	Counterterrorism Bureau
DUI	driving under the influence
DWI	driving while intoxicated
HVM	Hostile Vehicle Mitigation
KPH	kilometers per hour
NYC	New York City
NYC DOT	New York City Department of Transportation
NYPD	NYC Police Department
PAL	Publicly Accessible Locations
PC	police constable
RCCT	Rockefeller Center Christmas Tree
THPSS	target hardening/protective security spectrum
UK	United Kingdom
VADS	vehicle attack delay standards
VRA	vehicle ramming attack
VSB	vehicle security barrier
WTC	World Trade Center

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EXECUTIVE SUMMARY

Urban municipalities are full of pedestrian-rich environments with limited mitigation measures to prevent vehicle-caused pedestrian fatalities. Limited pedestrian protections both represent an attractive target for nefarious actors to commit vehicle ramming attacks and create a heightened risk of an accidental vehicle-caused pedestrian fatality. Stakeholders must leverage their intimate familiarity with their local environments, remain knowledgeable of emerging nefarious trends and tactics, and utilize various defensive-minded methodologies to protect the innocent within their pedestrian-rich environments.

A. REVIEW OF AVAILABLE INFRASTRUCTURE

This thesis identifies and examines the types of available infrastructure and illustrates the differences between permanent, semi-permanent, and temporary infrastructure. This thesis also identifies the rating systems utilized to gauge the effectiveness of the infrastructure. Various roadway design strategies, known as the streetscape methodology, are defined and examined to illustrate the techniques a stakeholder can utilize to further secure their environment from deadly vehicle-versus-pedestrian collisions and vehicle ramming attacks (VRA).

B. DEFENSIVE-MINDED METHODOLOGIES

This thesis identifies both the target hardening and protective security methodologies. Through this research, this thesis argues that both of these methodologies are homogenous and defensive minded. By utilizing the applicable share of both methodologies to protect pedestrian-rich environments, this thesis creates a new model: the target hardening/protective security spectrum (THPSS). THPSS is then dissected into the main dimensions: completely open, completely hardened, and the hybrid model, as they are the most common nationwide and are also the most easily delineated to a layman stakeholder. Each dimension of the THPSS is accompanied by at least one example of a real-world event or location within the United States.

C. CONCLUSIONS AND RECOMMENDATIONS

The research concludes that though many pedestrian-rich environments are vulnerable to vehicle-caused fatalities, there are defensive-minded methodologies and a homogenous framework for securing urban pedestrian-rich environments. The research identifies numerous urban policies, programs, events, and locations that can be improved to create a more secure environment for pedestrians from vehicle-caused fatalities:

1. Outdoor dining program managers must mandate measures to mitigate the risk of a vehicle-caused pedestrian fatality. If mitigation measures are deemed too costly or otherwise not able to be feasibly implemented, a permanent outdoor dining program should not be administered.

2. The use of the THPSS methodology can be applied to protecting street fair patrons from vehicle-caused fatalities. By utilizing the methodology, combined with their specific knowledge and expertise, stakeholders can implement the appropriate protective measures necessary to effectively make their environments more secure for pedestrians.

3. The New York City (NYC) Department of Transportation must take into consideration the possibility of a VRA at an NYC Open Streets event. The entire NYC Open Streets program must be either eliminated or significantly changed to include the content spelled out in this thesis.

4. The use of the THPSS methodology can be applied to protecting pedestrians at both large and small road races. Stakeholders of road races must utilize their knowledge of their respective events with the THPSS methodology to come up with practical ways to best protect their events from attack.

5. Many large urban public parks have gaps in their perimeter and possess limited infrastructure, which creates an avenue that nefarious actors can exploit. Stakeholders of large urban parks should survey their respective environments for these gaps and implement measures to mitigate VRAs from occurring within park boundaries.

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I. INTRODUCTION

A newly engaged couple is enjoying a Saturday afternoon walk in Manhattan. They come across a quaint street with local shops selling merchandise outside and restaurants that have set up areas to dine while enjoying the beautiful weather. The couple decides to patronize a restaurant and sit at an outside table. Soon after ordering their appetizer, screeches shatter the peaceful afternoon. They hear screaming and the increasing roar of a vehicle engine. As they turn to see the commotion, they see a large truck accelerating deep into the crowd of pedestrians and throwing shoppers' bodies aside like ragdolls. The couple has no time to get out of the way, and nothing can stop the truck from continuing its path toward them.

In recent years, vehicle ramming attacks (VRA) on soft targets have significantly increased worldwide, resulting in mass casualties.[1] The lethality and destruction that such terror tactics have incurred are apparent. Various policies in urban environments have put pedestrians at severe risk of not only becoming victims of a VRA but also victims of a deadly vehicle versus pedestrian collision. These local policies, such as the "Open Streets" program, have been implemented throughout New York City (NYC) and elsewhere in the United States.[2] However, these policies have seemingly not considered the recent trend of nefarious actors committing VRAs in the United States and other Western countries nor the everyday vehicle collision involving a pedestrian fatality.

This thesis aims to provide recommendations to stakeholders of pedestrian-rich environments to mitigate the possibility of vehicle-borne pedestrian fatalities. This thesis explores permanent, semi-permanent, and temporary infrastructure and how the use of this infrastructure can secure a pedestrian-rich environment from these deadly incidents. By exploring various pedestrian-rich environments in major metropolitan areas around the United States, this thesis seeks to consolidate and refine the concepts of target

[1] Brian Michael Jenkins and Bruce R. Butterworth, *An Analysis of Vehicle Ramming as a Terrorist Tactic* (San Jose, CA: Mineta Transportation Institute, 2018), 6, https://transweb.sjsu.edu/sites/default/files/SP0518%20Vehicle%20Ramming%20Terrorism.pdf.

[2] "Open Streets," Pedestrians, 2022, https://www1.nyc.gov/html/dot/html/pedestrians/openstreets.shtml.

hardening and protective security through the use of permanent, semi-permanent, and temporary infrastructure.

A. RESEARCH QUESTION

How can urban pedestrian-rich environments become more secure from vehicle-borne pedestrian fatalities and VRAs?

B. LITERATURE REVIEW

Scholars and other professionals use several defensive-minded methodologies to secure an asset. These methodologies range from theoretical frameworks to practical implementation tactics and policies. These defensive methodologies examine traditional hard targets such as government facilities and critical infrastructure. However, there are gaps in the literature when examined through the lens of this research question as the methodologies typically do not examine traditional soft targets such as pedestrian-rich environments. This literature review discusses various aspects of scholarly and governmental recommendations for defensive-minded methodologies as well as the academic debate regarding protective security and target hardening of a particular asset. Next, this literature review discusses roadway infrastructure by considering overt physical structures and methodologies regarding roadway design and streetscape principles.

1. Protective Security and Target Hardening

Protective security and target hardening are two independent defensive-minded theoretical frameworks. Both scholarly and governmental sources encapsulate each framework. Protective security is the implementation of effective measures that will help protect an asset from a threat.[3] Protective security uses five primary principles to protect an asset: "deterrence, detection, delaying, mitigation, and response."[4] Target hardening "is the last resort to resist crime by increasing physical security and is a more

[3] "Protecting Your Assets," Centre for the Protection of National Infrastructure, March 30, 2021, https://www.cpni.gov.uk/protecting-your-assets.

[4] Centre for the Protection of National Infrastructure.

recognizable, traditional way to discourage crime."[5] Lawrence Fennelly and Marianna Perry judge, "target hardening is not a fortress mentality concept; it is a good security practice."[6]

Literature on securing soft targets has begun to emerge in recent years because terrorists increasingly attack these targets since, according to Chalmers Johnson, "American soldiers and sailors seem invulnerable."[7] Protective security and target hardening have underlying commonalities when examined through the lens of securing soft targets from vehicle-borne threats. Jennifer Hesterman has emerged with literature focusing on securing soft civilian targets through the use of security training, deception, and layered physical security. Hesterman's literature, though applicable to different soft civilian targets, is not prescriptive as it focuses on large overarching issues. Various private security companies such as Watermark Risk Management also recommend using these tools. The United Kingdom's (UK) Centre for the Protection of National Infrastructure (CPNI) utilizes both the target hardening and protective security methodologies when examining how to secure soft targets from a variety of threats. In recent years, CPNI describes how "vehicles have been used as weapons to target, kill and injure pedestrians" in several global metropolitan centers.[8] Furthermore, CPNI has done extensive research into specific vehicle attack mitigation measures. Though this threat is acknowledged by many, literature specifically addressing the threat posed to pedestrian congregation, however, remains limited outside of CPNI's strategies and recommendations. Though CPNI's literature is more prescriptive than Hesterman's, this strategy of issuing general recommendations hinders the discussion and validity of the literature. No new frameworks of defensive-minded strategies have been introduced

[5] Lawrence J. Fennelly and Marianna A. Perry, *CPTED and Traditional Security Countermeasures: 150 Things You Should Know* (Boca Raton, FL: CRC Press, 2018), 10.

[6] Fennelly and Perry, 10.

[7] Chalmers Johnson, Blowback: The Costs and Consequences of American Empire (New York: Macmillan, 2000), 9.

[8] Paul Hess and Sneha Mandhan, "Ramming Attacks, Pedestrians, and the Securitization of Streets and Urban Public Space: A Case Study of New York City," *URBAN DESIGN International*, (2022): 1–16, https://doi.org/10.1057/s41289-022-00180-2.

despite "new tactics (emerging), as terrorists continually hit the 'reset button' with each attack."[9]

Government agencies, in the United States and abroad, have issued general advisories and recommendations to stakeholders about securing public assets in the form of concise literature. CPNI and the Cybersecurity and Infrastructure Security Administration (CISA) are two such agencies based in the UK and United States, respectively. CPNI and CISA both have similar functions but vary in scope. CPNI is responsible for issuing protective security advice to "reduce the vulnerability of the national infrastructure to terrorism and other threats."[10] CISA leads efforts to "understand, manage, and reduce risk" to both physical infrastructure and cyber infrastructure.[11] True to its name, CISA concentrates much more of its efforts on the cybersecurity realm than CPNI. Though both agencies have overlapping goals in their countries, the methods and strategies of execution vary.

CPNI and CISA act differently in their overall approach to issuing defensive advice. CPNI is methodological in its prescriptive approach to issuing recommendations whereas CISA is much broader in its overall mission. CISA, for example, has issued several concise action guides highlighting security awareness, including one explicitly addressing soft targets and crowded places. CISA specifically mentions standoff zones and vehicle access control as mitigation techniques to harden an asset or target.[12] Furthermore, CISA also describes various styles and designs of target hardening in another piece of concise literature titled "Protecting Patrons In Outdoor Eating

[9] Jennifer Hesterman, *Soft Target Hardening: Protecting People from Attack* (Boca Raton, FL: CRC Press, 2015), 1.

[10] "About CPNI," Centre for the Protection of National Infrastructure, August 9, 2021, https://www.cpni.gov.uk/about-cpni.

[11] "About CISA," Cybersecurity and Infrastructure Security Agency, accessed January 23, 2023, https://www.cisa.gov/about-cisa.

[12] Cybersecurity and Infrastructure Security Agency, "Vehicle Ramming: Security Awareness for Soft Targets and Crowded Places" (Washington, DC: Department of Homeland Security), accessed December 14, 2021, https://www.hsdl.org/?abstract&did=812645.

Venues."[13] These strategies resemble those represented by Fennelly and Perry and include practices such as conducting vulnerability assessments, implementing cost-effective protective measures, and even touching on some "suspicious behavior indicators."[14] These documents target managers, employees, and patrons of soft targets. While these sorts of recommendations are useful, it is difficult for CISA to issue meaningful protective security advice to individual stakeholders without one-to-one meetings or consultations.

Despite being located in and responsible for infrastructure protection within different countries, CPNI faces many of the same issues as CISA. CPNI's prescriptive approach to defense, though useful, is difficult to capitalize on without individual consultation and advice. CPNI does conduct lectures to governmental and private stakeholders with valuable information and expertise. However, these lectures typically address many institutions at once and are difficult to meaningfully address individual protective security issues. CPNI attempts to keep these lectures to singular general topics and address the relevant stakeholders. However, even when narrowly scoped, it remains difficult for CPNI to address the individual stakeholder's concerns based on unique environmental circumstances.

There has been some research exploring outdoor pedestrian open spaces within the past decade. The *Kansas Journal of Medicine,* for example, examined an Open Streets event and concentrated on topics such as economic impact and the "promotion of physical activity," while the research supporting the increased openness of pedestrian areas largely overlooks various threats such as nefarious actors.[15] Other academic works, such as those led by Andrew Chee, Keng Lee, Hannah Jordan, and Jason Horsely, point

[13] Cybersecurity and Infrastructure Security Agency, "Protecting Patrons in Outdoor Eating Venues" (Washington, DC: Department of Homeland Security, 2021), https://www.cisa.gov/sites/default/files/publications/CISA_Protecting%20Patrons%20in%20Outdoor%20Eating%20Venues_Fact%20Sheet_508.pdf.

[14] Cybersecurity and Infrastructure Security Agency.

[15] Danielle Gauna et al., "An Evaluation of a Kansas Open Streets Event's Impact on Businesses," *Kansas Journal of Medicine* 14, no. 2 (2021): 187–91, https://doi.org/10.17161/kjm.vol1414662.

to the sociological and mental health benefits that these environments provide.[16] This field also features topics such as racial equity, "civic engagement values," and "social, environmental, and economic benefits," as discussed by Sanjukta Hazarika.[17] Hesterman's discussion of open pedestrian spaces largely refers to general risk management at locations considered to be soft targets. Though Hesterman does provide some relevant recommendations for protecting soft targets, they consist mainly of after-action criticisms and, at times, vague generalization to generic locations. Most research looking into outdoor pedestrian-rich environments do not explicitly address public safety threats from criminality or terrorism.

Risk management and analysis have the possibility of playing a significant role in identifying target-hardening actions; however, limited research uses any soft hybrid model or a risk matrix regarding soft targets.[18] Accordingly, as Dora Kotkova, Lukas Kralik, and Lukas Kotek discuss, "there are many risk analysis methods. However, only some of them are suitable for the soft targets."[19] The research in this field, such as that of Ben Sheppard's, primarily uses foreign examples, although the September 11, 2001, terror attacks on the United States figure in this scholarship.[20] Sheppard's research focuses on chemical, biological, radiological, nuclear, and explosive threats, making it limited in scope. Other modern scholarly work conducted by Paul Hess and Sneha Mandhan concerns the "securitization of streets and urban public space" that attempts to fill in the many existing gaps.[21] Hess and Mandhan take the research one step further by

[16] Andrew Chee Keng Lee, Hannah C. Jordan, and Jason Horsley, "Value of Urban Green Spaces in Promoting Healthy Living and Wellbeing: Prospects for Planning," *Risk Management and Healthcare Policy* 8 (2015): 131–37, https://doi.org/10.2147/RMHP.S61654.

[17] Sanjukta Hazarika, "'On Reclaiming the Streets for the People': Understanding Equity in Public Space Planning Strategies Through an Analysis of the Open Streets Program in New York City" (master's thesis, Columbia University, 2021), 69, https://doi.org/10.7916/d8-ad9g-0g98.

[18] Dora Kotkova, Lukas Kralik, and Lukas Kotek, "Multiple Criteria Decision-Making: Risk Analyses for Cultural Events as One of the Soft Target Categories," in *2021 International Carnahan Conference on Security Technology (ICCST)*, 2021, 1–6, https://doi.org/10.1109/ICCST49569.2021.9717382.

[19] Kotkova, Kralik, and Kotek.

[20] Ben Sheppard, "Mitigating Terror and Avoidance Behavior through the Risk Perception Matrix to Augment Resilience," *Journal of Homeland Security and Emergency Management* 8, no. 1 (2011): 131–37, https://doi.org/10.2202/1547-7355.1840.

[21] Hess and Mandhan, "Ramming Attacks, Pedestrians, and the Securitization."

tailoring risk management and analysis to urban outdoor locations. Hesterman describes a spectrum of hardening actions that can be taken "from nothing to everything, from inexpensive to exorbitantly expensive."[22] Academic literature discussing any sort of hybrid model of openness and target hardening is limited in the framework because of its largely theoretical approach, as mentioned by Hesterman's "spectrum of hardening actions."[23] Essentially, risk management and analysis, though useful in general strategic planning, is difficult to tailor to specific environments.

2. Road Infrastructure

Road infrastructure includes not only the roadway but also the physical structures and mechanisms designed and implemented to channel traffic to and from an area. This research examines systems of infrastructure and how they can be utilized by stakeholders and government agencies to better secure pedestrian-rich environments from vehicular-borne threats.

3. Overt Physical Structures

Overt physical structures, or vehicle security barriers, are physical and visual barriers that are used to prevent vehicles from gaining unwanted access to an area. Various government agencies throughout the world, such as CISA and CPNI, broadly discuss the strengths and limitations of overt physical structures and specifically mention their design features as a major contributing factor in their analysis. These design features include activity, foundation, style, and operation.[24] Independent security companies and contractors similarly discuss these design features and include governmental recommendations and analysis.

These same government agencies, however, are hesitant to issue blanket statements that vehicle security barriers (VSBs) with certain design features are fail-safe.

[22] Hesterman, 201.

[23] Hesterman, 201.

[24] Centre for the Protection of National Infrastructure, "HVM - Impact Rated - Rating System Explained" (London, England: Centre for the Protection of National Infrastructure, February 1, 2021), 9, https://www.cpni.gov.uk/sites/default/files/citvsb_catalogue/CSE%20HVM%20-%20Impact%20Rated%20-%20Rating%20System%20Explained%20-%2020210201_0_0.pdf.

As stated by CISA, VSB design features are discussed and illustrated with the intent to provide context to stakeholders in their quests to protect "a particular site requiring restricted access."[25] CPNI has developed test methods and standards to gauge the effectiveness of overt physical structures that are recognized and accepted by other governmental agencies and private security companies in the international community, giving credence to the methodology.

4. Roadway Design and Streetscape

According to the University of Delaware and the Delaware Department of Transportation, streetscape is "the natural and built fabric of the street and defined as the design quality of the street and its visual effect."[26] The streetscape methodology consists of design options that "security professionals should consider when looking to protect streets and other Publicly Accessible Locations (PAL) from" hostile vehicles.[27]

The debate surrounding streetscape principles consists mostly of recommendations from governmental institutions such as CPNI and CISA. These governmental institutions recommend utilizing streetscape principles to protect a singular static hard target such as a power plant or a dam.[28] There is little mention of utilizing streetscape principles to secure pedestrian-rich environments. Any such mention from these governmental authorities is overly vague and consists of phrases such as "evaluate vehicle traffic patterns" and "implement strategies to reduce vehicle speeds."[29] Academic work has emerged in recent years surrounding the susceptibility to mass gatherings to

[25] "Guide to Active Vehicle Barrier (AVB) Specification and Selection Resources," Cybersecurity and Infrastructure Security Agency, 2020, 2, https://www.cisa.gov/sites/default/files/publications/Guide-to-Active-Vehicle-Barrier-2014-508.pdf.

[26] Complete Communities Toolbox, "Streetscaping," Streetscaping, accessed January 14, 2023, https://www.completecommunitiesde.org/planning/complete-streets/streetscaping/.

[27] Centre for the Protection of National Infrastructure, "HVM Schemes for the Streetscape" (London, England: Centre for the Protection of National Infrastructure, March 2021), 3, https://www.cpni.gov.uk/resources/cpni-hvm-schemes-high-street.

[28] Cybersecurity and Infrastructure Security Agency, *Dams Sector: Active and Passive Vehicle Barriers Guide* (Washington, DC: Cybersecurity and Infrastructure Security Agency, 2020), 1, https://www.cisa.gov/sites/default/files/publications/CISA_Dams_Sector_Active_and_Passive_Vehicle_Barriers_Guide_100220_508.pdf.

[29] Cybersecurity and Infrastructure Security Agency, "Vehicle Ramming."

VRAs; however, these works are broad in scope in that they consider several different terror tactics, such as edged weapons and bombings, in their analysis.[30]

C. RESEARCH DESIGN

This thesis used two approaches to guide stakeholders of pedestrian-rich environments to mitigate the possibility of vehicle-borne pedestrian fatalities. The first component defines permanent, semi-permanent, and temporary infrastructure by using a comparative analysis approach. This thesis examined the infrastructure design features and rating systems to properly define permanent, semi-permanent, and temporary infrastructure. This component also examines the streetscape methodology for its ability to limit pedestrian vulnerability to vehicle-borne threats.

The second component of this thesis examined both the target hardening and protective security methodologies using a theoretical analysis model. This thesis examined the possibility of combining the protective security and target hardening methodologies into one homogenous defensive methodology. This was done by examining the interventions of permanent, semi-permanent, and temporary infrastructure at real-world events and locations. This component analyzed various prevalent urban pedestrian-rich environments ranging from large-scale planned events to common day-to-day conditions. The thesis explored and defined three dimensions of this homogenous methodology: "completely open," "completely hardened," and "hybrid model." These three options were chosen as primary dimensions of this homogenous methodology because of their widespread practical application throughout the United States. For example, this thesis explored New York City's Summer Streets Program for the "completely open" model, the World Trade Center (WTC) site for the "completely hardened" model, and the 2022–2023 Rockefeller Christmas Tree site for the "hybrid model." The author utilized his position within NYC law enforcement to explore some of these various real-world environments in person while others were explored through research.

[30] Patrick E. Mullane, "Political Demonstrations: A Terrorist's Dream Opportunity" (master's thesis, Naval Postgraduate School, 2020), 88, https://www.hsdl.org/?abstract&did=839418.

Ultimately, based on the comparative analysis of permanent, semi-permanent, and temporary infrastructure and the theoretical analysis of various defensive-minded methodologies, this thesis makes several judgments and recommendations. It concludes with recommendations to stakeholders, particularly in NYC, identifying how to better secure several different types of urban pedestrian-rich environments. More broadly, this thesis also issues recommendations to employ the target hardening/protective security spectrum in the site security plans of managers of urban pedestrian-rich environments.

D. THESIS OVERVIEW

This thesis begins with a comparative analysis of presently available infrastructure design features and ratings with streetscape methodologies and provides an understanding of the various tactics that can be employed to defend urban pedestrian-rich environments. The thesis then shifts to examine both the protective security and target-hardening methodologies by using a theoretical analysis model. Finally, this thesis provides recommendations, both specific to NYC and more broadly, to fix vulnerabilities in urban pedestrian-rich environments.

II. REVIEW OF AVAILABLE INFRASTRUCTURE

A substantial number of companies manufacture and install infrastructure components that have varying abilities to stop vehicle-caused pedestrian fatalities and VRAs. There are also design strategies that stakeholders can implement to reduce the likelihood and overall impact of a vehicle-borne threat in a specific environment. This chapter defines permanent, semi-permanent, and temporary infrastructure by identifying and examining various vehicle security barrier design features and the rating systems used to gauge their effectiveness. Each category of infrastructure is accompanied by three examples in Appendix C. The rating system for the infrastructure is separated into two categories: impact rated and vehicle attack delay standard, with accompanying examples in Appendix A. Roadway design strategies, known as streetscape, are also examined to provide greater depth to the author's target hardening/protective security spectrum (THPSS) model, which is examined in Chapter III.

CPNI has shown a considerable wealth of knowledge and dedication to securing pedestrian-rich environments through the use of VSBs within the UK. Other governmental agencies throughout the world, such as CISA, have shown a working understanding and knowledge of the subject through literature publication and engagement with public and private entities. CPNI has broken down infrastructure and VSB design features to give stakeholders appropriate context when selecting which type of infrastructure should be selected for a particular environment.[31] CPNI has shown a wealth of knowledge in this area with its detailed breakdown of VSB design features and other mitigation methods.

The aim of this chapter is to define what permanent, semi-permanent, and temporary infrastructure is based on that infrastructure's ratings and design features. The various categories of infrastructure can be implemented in a wide variety of pedestrian-

[31] Centre for the Protection of National Infrastructure, "CPNI Advice Note: Due Diligence in the Selection and Procurement of Vehicle Security Barriers" (London, England: Centre for the Protection of National Infrastructure, June 18, 2019), 1, https://www.cpni.gov.uk/system/files/documents/40/81/Advice%20Note%20-%20Due%20Diligence%20in%20selecting%20barriers%20-%2003%20March%202020%20v3.pdf.

rich environments ranging from indefinite site security planning to singular events lasting for a constrained period of time. By defining these categories of infrastructure using a comparative analysis approach, this chapter seeks to illustrate that stakeholders can tailor their defensive strategies based on the categorical designation of infrastructure and their unique environmental circumstances.

A. PRINCIPLES, DEFINITIONS, AND CATEGORIZATION OF VSBs

This section lays out the principles, definitions, and categorization of VSBs from permanent to semi-permanent to temporary. By spelling out the principles, definitions, and various categorizations of VSBs, this section aims to establish a framework for THPSS, which are examined in Chapter III. This section aims to illustrate the differences between permanent, semi-permanent, and temporary infrastructure. Appendix C contains three examples for each category of infrastructure. By breaking down the principles and definitions of VSBs and considering an environment's strengths, weaknesses, needs, challenges, and capabilities, this section makes the following assertions:

- Permanent infrastructure is best suited for high-traffic locations with pedestrian-dense foot traffic.
- Semi-permanent infrastructure is best suited for environments with ongoing security concerns that could last indefinitely.
- Temporary infrastructure is best suited for locations and events with short-term security concerns.

1. Permanent Infrastructure

Permanent infrastructure has an overall design that is intended to remain unchanged indefinitely. Permanent infrastructure is usually passive, contains no moving parts, has some sort of foundational depth, and is rated to withstand a vehicle impact. Environments utilizing permanent infrastructure typically have long-term security concerns and have an increased possibility of a vehicle-caused pedestrian fatality due to heavy traffic volume and regular heavy pedestrian flow. By implementing permanent

infrastructure, stakeholders can establish an environment with a high level of security from deadly vehicle- versus- pedestrian collisions and VRAs on a long-term basis.

Categorically designated permanent infrastructure is best suited for high-traffic locations with pedestrian-dense foot traffic. When a location maintains a high traffic volume and regular heavy pedestrian flow, there is an increased possibility of a deadly vehicle-versus-pedestrian collision or a VRA. Examples of locations with permanent infrastructure include the WTC site and the U.S. Capitol Building. Permanent infrastructure offers stakeholders the best option to protect pedestrians within these environments from vehicle-borne threats. Figure 1 illustrates the attributes of permanent infrastructure.

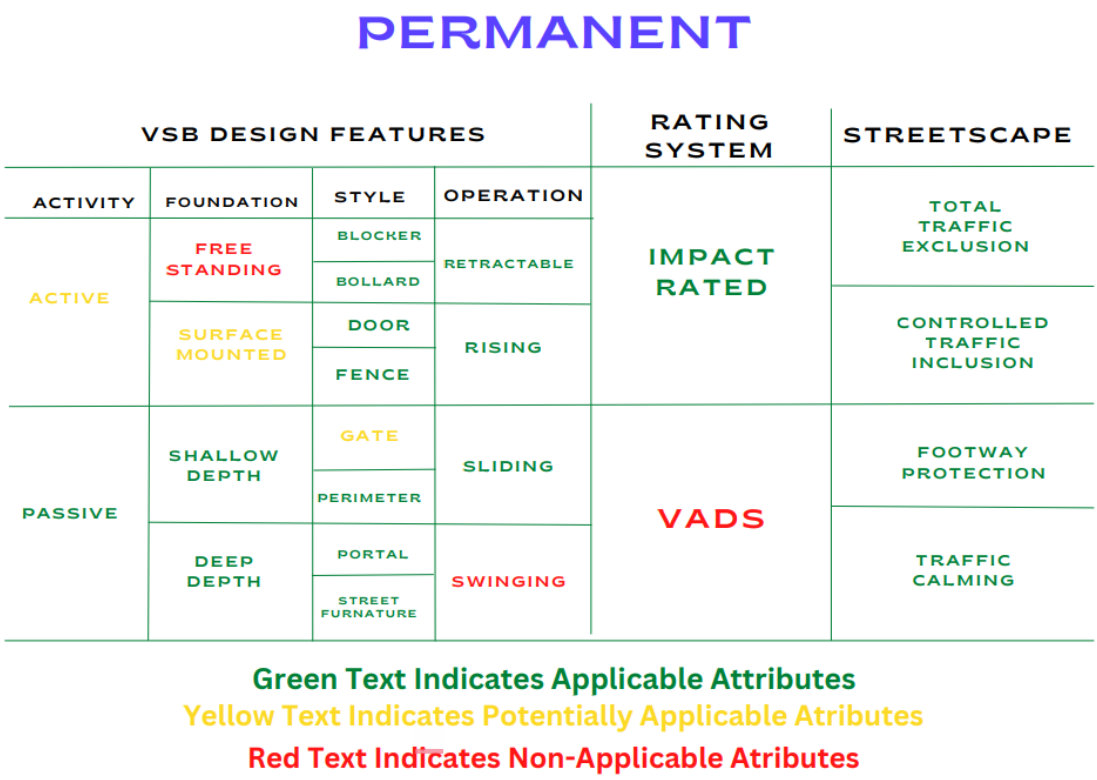

Figure 1. Permanent Infrastructure Attributes

2. Semi-permanent Infrastructure

Semi-permanent infrastructure is designed with some sort of endurance and stability on a near-term basis. Semi-permanent infrastructure can be either active or passive, does not have foundational depth, and is rated to withstand a vehicle impact. Environments utilizing permanent infrastructure typically have near-term, though not necessarily permanent, security concerns. Semi-permanent infrastructure is best utilized in environments that are likely to see an increased quantity of pedestrians in the vicinity of a sustained flow of traffic. By implementing semi-permanent infrastructure, stakeholders are able to establish an environment with a moderate amount of security to protect against deadly vehicle-versus-pedestrian collisions and VRAs.

Categorically designated semi-permanent infrastructure is best suited for environments with ongoing security concerns that could last indefinitely. Semi-permanent infrastructure can be redeployed to another location after being installed, though not in a rapid fashion as it is designed to remain at a location indefinitely. Examples of locations that have used semi-permanent infrastructure include Trump Tower and Rockefeller Center in NYC. Semi-permanent infrastructure allows stakeholders effective protection mechanisms from vehicle-borne threats while simultaneously affording flexibility as unique circumstances change. Figure 2 illustrates the attributes of semi-permanent infrastructure.

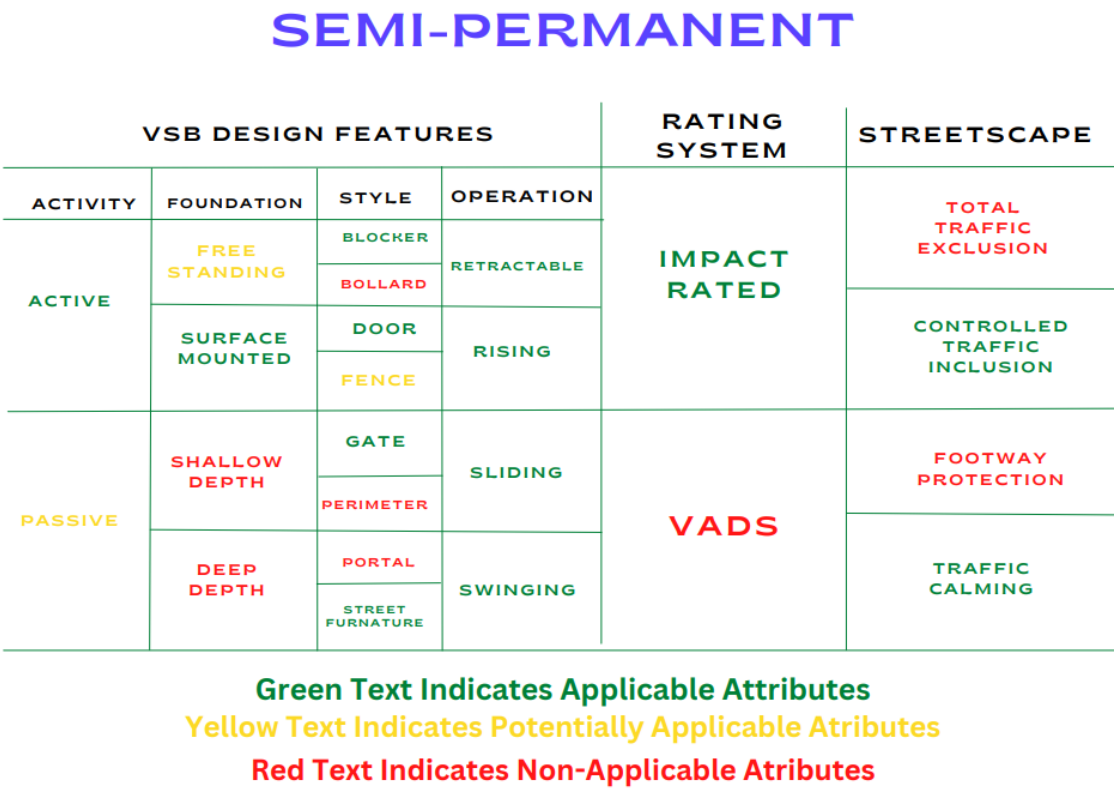

Figure 2. Semi-Permanent Infrastructure Attributes

3. Temporary Infrastructure

Temporary infrastructure has an overall design that is intended to change in a short period of time relative to environmental conditions. This type of infrastructure is widely used in conjunction with temporary events that last hours or days and operate in a way that allows the stakeholder to return the environment to its original form. Temporary infrastructure is best used in environments that will see an unusually large number of pedestrians in a particular area for a brief period in which vehicle access is normally allowed.

Temporary infrastructure is typically active in nature, has no foundational depth, meets vehicle attack delay standards (VADS), and can be redeployed in an expeditious fashion. Environments utilizing temporary infrastructure typically have short-term security concerns. By implementing temporary infrastructure, stakeholders can establish an environment with a moderate level of security from vehicle-borne threats on a short-

term basis while also allowing the environment to return to its normal design and function after the security concerns have come to an end.

Categorically designated temporary infrastructure is best suited for locations and events with short-term security concerns. These locations and events typically allow many pedestrians to congregate for a constrained period within an area that is normally accessible to vehicles. This temporary infrastructure creates separation space from vehicles for pedestrians on a near-term basis. Rapid redeployment of this infrastructure to another location is possible and allows stakeholders to return the environment to its original design and purpose. Temporary infrastructure is utilized at events that have set beginning and end times. Examples of events that have used temporary infrastructure include both the Boston and NYC Marathons. This type of infrastructure allows stakeholders a lower level of protection from vehicle-borne threats while simultaneously allowing the environment to return to its normal design and function after the event has concluded. Figure 3 illustrates the attributes of temporary infrastructure.

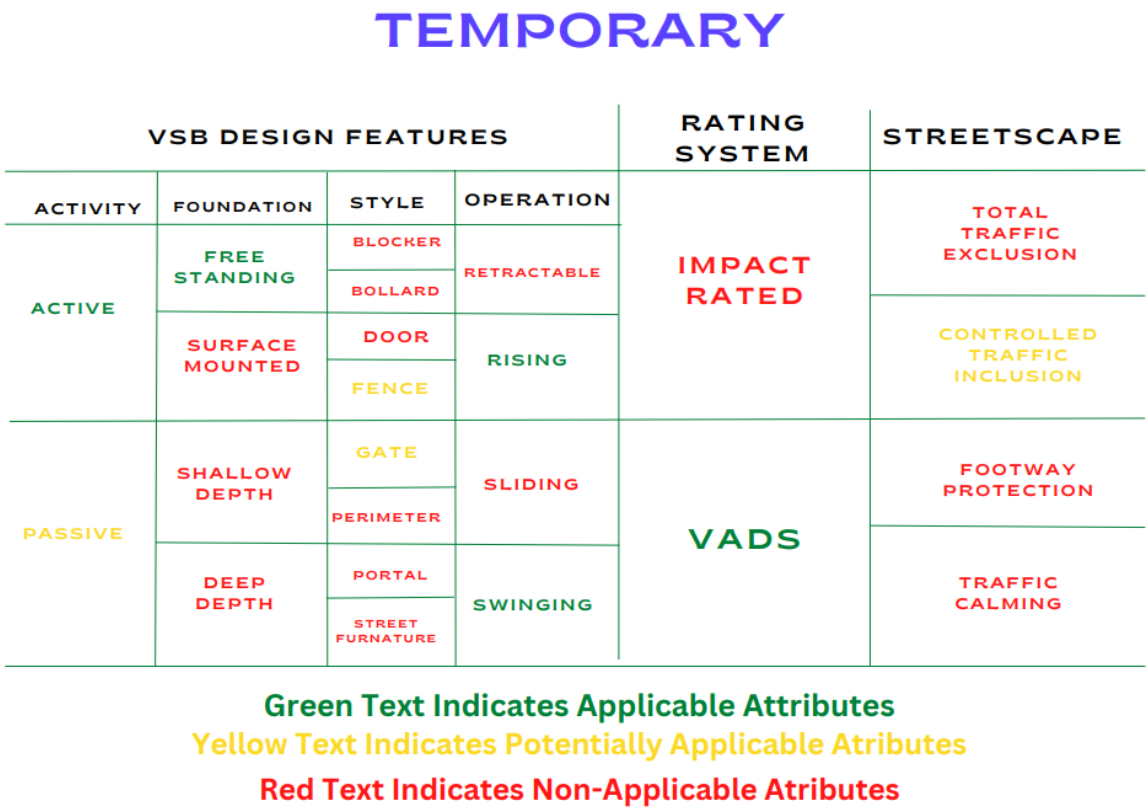

Figure 3. Temporary Infrastructure Attributes

4. Vehicle Security Barrier Design Features

This section lays out the design features used to consider if a particular piece of infrastructure should be designated as either permanent, semi-permanent, or temporary. By laying out the design features, this section aims to draw conclusions as to which VSB design features are prevalent in permanent, semi-permanent, and temporary designations.

Several elements of VSBs must be examined to properly categorize infrastructure. CPNI spells out "several parameters that enable the user to filter down prospective VSBs based on the operational and user requirements."[32] CPNI argues that stakeholders should

[32] Centre for the Protection of National Infrastructure, "HVM - Impact Rated - Rating System Explained," 9.

make VSB selections "based on a security Operation Requirement and a detailed specification."[33]

CPNI describes four VSB design features that must be considered by "the user to filter down prospective VSBs based on the operational and user requirements."[34] These characteristics include the activity, foundation, style, and operation of the specific infrastructure.[35] The specific details of each characteristic are discussed in the following sections. By examining the design features, this chapter seeks to establish a framework for how permanent, semi-permanent, and temporary infrastructure is defined.

B. ACTIVITY

CPNI asserts that the activity of a VSB must be taken into account when considering what type of category to designate a piece of infrastructure.[36] Activity is defined as the movement, or lack thereof, of a VSB.[37] The subsects of the activity category are "active" and "passive."[38] Active infrastructure is an apparatus that may be manipulated by the user to enable the passage of vehicles;[39] passive infrastructure is a fixed apparatus with no moving components.[40]

As described above, the activity of a VSB has two subsects. The designation of the activity subsect of a VSB will depend if the VSB is static or if it has any moving parts necessary for its functionality. A passive VSB is more likely to be a permanent piece of infrastructure as it does not allow vehicles to pass. An active VSB does allow vehicle movement through the utilization of moving parts and is therefore more likely to be categorized as semi-permanent or temporary infrastructure.

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[33] Centre for the Protection of National Infrastructure, "CPNI Advice Note," 1.

[34] Centre for the Protection of National Infrastructure, "HVM - Impact Rated - Rating System Explained," 9.

[35] Centre for the Protection of National Infrastructure, 9.

[36] Centre for the Protection of National Infrastructure, 9.

[37] Centre for the Protection of National Infrastructure, 9.

[38] Centre for the Protection of National Infrastructure, 9.

[39] Centre for the Protection of National Infrastructure, 9.

[40] Centre for the Protection of National Infrastructure, 9.

C. FOUNDATION

CPNI asserts that the foundation of a VSB must be taken into account when considering what type of category to designate a piece of infrastructure.[41] "Foundation" is defined as the "amount of ground depth required" to ensure the piece of infrastructure can function as designed.[42] There are four subsects of the foundation category according to CPNI: (1) a piece of infrastructure that is freestanding has no ground fixings; (2) surface-mounted piece of infrastructure that is pinned or bolted to the ground; (3) a shallow-depth piece of infrastructure has a depth less than or equal to .5 meters below ground level; and (4) a deep-depth piece of infrastructure has a depth greater than .5 meters below ground level.[43]

As described above, the foundation of a VSB has four subsects. The designation of the foundation subsect of a VSB will depend on if the VSB possesses any substructural aspects. A VSB will be considered permanent if it possesses any level of structural depth due to the time and labor associated with installation. It will also be considered permanent due to its inability to move or be transported after its initial installation. A freestanding VSB will be considered either semi-permanent or temporary due to its ability to move or be transported in a short period of time relative to a VSB with foundational depth.

D. STYLE

CPNI asserts that the style of a VSB must be taken into account when considering what type of category a piece of infrastructure is designated.[44] Each style has different functions.[45] The following list summarizes the subsects of the style category according to CPNI.[46]

[41] Centre for the Protection of National Infrastructure, 9.

[42] Centre for the Protection of National Infrastructure, 9.

[43] Centre for the Protection of National Infrastructure, 9.

[44] Centre for the Protection of National Infrastructure, 9.

[45] Centre for the Protection of National Infrastructure, 9.

[46] Centre for the Protection of National Infrastructure, 9.

1. Blocker: an active access control unit that typically retracts back into the ground
2. Bollard: a fixed post or an active access control post that typically retracts back into the ground
3. Door: an active access control system in a wall
4. Fence: a continuous passive barrier with no moving components designed to exclude both vehicles and pedestrians
5. Gate: an active access control system that typically rises, swings, or slides to allow access
6. Perimeter: a continuous physical border that prevents vehicle passage.
7. Portal: an access point for pedestrians that is typically part of a perimeter
8. Street furniture: passive objects that are vehicle- impact rated that also serve a public realm purpose

As shown above, the style of a VSB has eight subsects. The designation of a subsect of a VSBs style will depend on the specific functional aspects the VSB possesses. The consideration of the specific style a VSB possesses is not as crucial in determining its categorization as its activity or foundation. The style of a VSB generally represents its aesthetic look and the manner in which it operates and is therefore imperfect at judging the appropriate categorization. There are, however, some styles of VSBs that will always be designated into one category of infrastructure. A bollard, for example, is an inherently passive piece of infrastructure with foundational depth and will always be considered permanent. In sum, the function of a VSB can be considered, but is not always crucial, when categorizing the VSB as permanent, semi-permanent, or temporary.

E. OPERATION

CPNI asserts that the method of operation of a VSD must be taken into account when considering what type of category a piece of infrastructure is designated.[47]

[47] Centre for the Protection of National Infrastructure, 10.

Operation is defined as the motion in which active VSBs allow vehicular access.[48] The operational mechanisms listed below only apply to active VSBs as only active VSBs possess moving components. Each operational mechanism has specific workings. The following list summarizes the subsects and specific workings of the operational category according to CPNI.[49]

1. Retractable: vertical or rotating movement in the vertical plane, toward ground level
2. Rising: vertical or rotating movement in the vertical plane, away from ground level
3. Sliding: horizontal movement to the side
4. Swinging: pivoting on the horizontal plane

As shown above, the operation of a VSB has four types of specific workings. The designation of a subsect of a VSB's operation will depend on the specific workings the VSB possesses. Similar to the style feature, the consideration of a VSBs operation is not as crucial in determining its categorization as its activity or foundation. The operation of a VSB generally represents its manner of function and is therefore imperfect at judging the appropriate categorization. In sum, the function a VSB utilizes for its operability can be considered, but is not crucial, when categorizing the VSB as permanent, semi-permanent, or temporary.

F. RATING SYSTEM

This section lays out the two general rating systems regarding hostile vehicle mitigation (HVM) infrastructure: impact-rated and VADS. CPNI utilizes these rating systems "to assess the vehicle impact performance of VSBs."[50] This section aims to

[48] Centre for the Protection of National Infrastructure.

[49] Centre for the Protection of National Infrastructure, 10.

[50] Centre for the Protection of National Infrastructure, "Impact Testing of Vehicle Security Barriers" (London, England: Centre for the Protection of National Infrastructure, August 2020), 4, https://www.cpni.gov.uk/system/files/documents/26/e5/CPNI%20-%20Impact%20Testing%20of%20Vehicle%20Security%20Barriers%20-%2018%20August%202020%5b2%5d.pdf.

establish further context on how permanent, semi-permanent, and temporary infrastructure are defined. By spelling out the two general rating systems in which the effectiveness of a piece of infrastructure is assessed, this section also intends to further establish a framework for the THPSS, which is examined in Chapter III. This section further intends to illustrate the differences between VADS and impact-rated VSBs while discussing pedestrian-rich environments that should utilize VSBs with each rating.

1. Impact-Rated VSBs

According to CPNI, impact-rated VSBs are infrastructure that will have the capacity to withstand an impact from an "unmodified road vehicle travelling at a specified speed."[51] Impact-rated infrastructure is either permanent or semi-permanent in nature, depending upon how it has been tested.[52] Impact-rated infrastructure is applicable to locations in which stakeholders fear a deadly vehicle versus pedestrian collision or VRA is more likely to occur. These locations can include those with a high traffic volume and regular heavy pedestrian flow. By implementing infrastructure that has been impact rated into their specific environments, stakeholders are able to establish a domain with a high level of protection from vehicle versus pedestrian collisions and VRAs.

According to CPNI, VSBs that are designated impact-rated are generally tested to "one (or more) of the following test methods (informally known as 'standards'): ISO IWA 14-1:2013, BSI PAS 68, CEN CWA 16221:2010, and BSI PAS 170–1:2017."[53] For a VSB to be considered impact-rated, "all full scale vehicle impact tests require a vehicle to impact the VSB. Numerous vehicles are used across the standards."[54] There are also a variety of factors that will determine the performance capability of the VSB including the mass, size, and structure of the vehicle as well as the speed and impact angle.[55] The types of vehicles used in the testing process include a double axle car, a 4x4 crew or single cab

[51] Centre for the Protection of National Infrastructure, 3.

[52] Centre for the Protection of National Infrastructure, 5–6.

[53] Centre for the Protection of National Infrastructure, "HVM - Impact Rated - Rating System Explained," 4.

[54] Centre for the Protection of National Infrastructure, 5.

[55] Centre for the Protection of National Infrastructure, 5.

pick-up, impact trolley, and several multi-axle day cab trucks.[56] Helping to clarify these test methods, a summary and breakdown of each method appear in Appendix A.

Impact-rated VSBs can either be designated as permanent or semi-permanent infrastructure due to their ability to withstand vehicle impacts. Temporary VSBs are never impact rated as they only meet VADS standards. As such, pedestrian-rich environments with long-term concerns over vehicle-caused pedestrian fatalities utilize impact-rated VSBs to create a more secure environment for pedestrians.

2. Vehicle Attack Delay Standard

The CPNI has also developed a type of infrastructure standard called "VADS."[57] According to the CPNI, "VADS provides a means for testing Vehicle Security Barriers (VSBs) against aggressive and repetitive vehicle impacts."[58] CPNI implies that VADS-rated infrastructure has not undergone the same rigorous testing as impact-rated infrastructure by describing it as pragmatic and affordable.[59] By implementing VADs infrastructure, stakeholders are afforded a more cost-effective but less secure option to protect their environment from VRAs and deadly vehicle versus pedestrian collisions.

VSBs that possess a VADS rating are not a permanent solution that a stakeholder can implement to mitigate the possibility of a vehicle-borne threat. VADS-rated VSBs are designed "typically for, but not exclusively, temporary events" such as small parades, street festivals, and farmer's markets.[60] By implementing infrastructure that has been VADS rated into their specific environments, stakeholders can establish a moderate level of protection from vehicle versus pedestrian collisions and VRAs at temporary pedestrian-rich events.

[56] Centre for the Protection of National Infrastructure, 5.

[57] "CSE Chapter: HVM - Delay Rated," Centre for the Protection of National Infrastructure, 2022, https://www.cpni.gov.uk/cse-chapter-hvm-delay-rated.

[58] Centre for the Protection of National Infrastructure.

[59] Centre for the Protection of National Infrastructure.

[60] Centre for the Protection of National Infrastructure.

Stakeholders are afforded a more flexible option when utilizing VADS-based VSBs. Implementing VADS infrastructure provides "an alternative risk-based option for event managers and other risk owners."[61] VADS-rated infrastructure is best used at temporary events that will see an unusually large number of pedestrians in a particular area for a brief period in which vehicle access is normally allowed. By implementing VADS infrastructure, there is a tradeoff a stakeholder must weigh between the higher protection standard of impact-rated infrastructure and the affordability of VADS infrastructure.

VADS VSBs can only be designated as temporary infrastructure due to the lower level of protection afforded compared to impact-rated VSBs. VSBs that only meet the VADS standard have no place in environments that have long or near-term security concerns. As such, pedestrian-rich environments with short-term security concerns over vehicle-caused pedestrian fatalities can utilize VADS VSBs to create a more secure temporary event while allowing the environment to revert to its original design and function after the event has concluded.

G. STREETSCAPE

This section defines and examines various streetscape design methodologies including total traffic exclusion, controlled traffic inclusion, footway protection, and traffic calming. By spelling out these streetscape design methodologies, this section aims to further establish a framework for the THPSS, which is examined in Chapter 3. This section aims to break down the available techniques stakeholders can use to further secure their environment from vehicle-caused pedestrian fatalities through the lens of overall streetscape practices.

1. Streetscape Principles and Definitions

This section lays out the streetscape principles and definitions. This section aims to illustrate how common streetscape practices came into being by providing a brief historical context. By spelling out the streetscape principles and definitions, this section

[61] "Certificates," Unafor, 2021, https://unafor.com/certificates/.

also aims to further establish a framework for the THPSS, which is examined in Chapter III.

2. General Streetscape Methodology

Throughout the United States, street layout has been designed decades or even centuries ago. In some cases, such as Broadway in NYC, roadway design can originate from incredibly old transportation passages such as Native American trails.[62] As time has progressed, buildings, parks, and various other mechanisms have further cemented overall roadway design and flow. Because the flow and design of the overall roadway are antiquated, it is incredibly difficult for stakeholders to implement new roadway design techniques to further protect their environment from deadly vehicle-versus-pedestrian collisions and VRAs.

As street infrastructure has long been a staple in urban design, it is incredibly difficult to simply re-engineer a street, its direction of travel, or vehicular flow. As stated by Paul Hess and Sneha Mandhan, "there is minimal intentional alignment between anti-terrorism security and traffic safety designs."[63] As such, stakeholders are typically forced to work around the roadway design to implement mitigation tactics using available infrastructure if they desire to protect an area from a vehicle-borne threat. It may not be feasible for some roadways to be completely re-designed due to the cost, surrounding buildings, or landscape; however, in many circumstances it is possible to manipulate the surrounding environment to mitigate against hostile vehicles.

The streetscape methodology "centres on Hostile Vehicle Mitigation (HVM) schemes that may be deployed in streets in cities and towns."[64] There are a number of streetscape practices that local stakeholders can implement to better secure their environments from vehicle versus pedestrian collisions and VRAs. However, according to the CPNI, "a well-considered HVM scheme envisioned at the earliest possible stages of a new development or a redevelopment project should complement the aesthetic,

[62] Michelle Young, *Broadway*, Images of America (Charleston, SC: Arcadia Publishing, 2015), 7.

[63] Hess and Mandhan, "Ramming Attacks, Pedestrians, and the Securitization," 14.

[64] Centre for the Protection of National Infrastructure, "HVM Schemes for the Streetscape," 3.

business and functional needs of the area. The project should incorporate security planning from the outset" of project design.[65] By implementing one or more defensive streetscape design techniques into their specific environments, stakeholders can apply overt mitigation practices to better secure pedestrian-rich environments from deadly vehicle-versus-pedestrian collisions and VRAs.

H. PROMINENT STREETSCAPE DESIGN METHODS

There are several ways to utilize streetscape design methods in a permanent fashion to mitigate vehicle-caused pedestrian fatalities. According to the CPNI, although there are several methods in which streetscape design methods can be implemented in a specific environment, only four of these methods can be imposed on a permanent basis: total traffic exclusion, controlled traffic inclusion, footway protection, and traffic calming.[66] By laying out these various streetscape design methods, this section aims to provide the reader with the proper context of how each specific method, when implemented in a permanent environment, can provide valuable defensive benefits against vehicle-caused pedestrian fatalities and VRAs.

1. Total Traffic Exclusion

Total traffic exclusion is the ultimate streetscape practice to protect a pedestrian-rich environment from vehicle-caused pedestrian fatalities. According to CPNI, total traffic exclusion "carries the lowest risk of a Vehicle As a Weapon Attack and also maximizes blast stand-off distance."[67] In this model, pedestrians are protected simply by being in an environment that is inaccessible to vehicles. According to the CPNI, total traffic exclusion can be implemented by using "permanent passive vehicle security barriers at all routes leading into the protected area."[68] By effectuating total traffic exclusion, stakeholders can effectively eliminate the risk level of a vehicle-caused pedestrian fatality in their specific environment.

[65] Centre for the Protection of National Infrastructure, 3.

[66] Centre for the Protection of National Infrastructure, 11.

[67] Centre for the Protection of National Infrastructure, 12.

[68] Centre for the Protection of National Infrastructure, 12.

Total traffic exclusion also has operational drawbacks for stakeholders. Since all vehicles are eliminated from the protected area, innocuous vehicles such as those used for deliveries and emergencies are also excluded and "require alternative traffic management plans."[69] For an effective total traffic exclusion plan to be put into place, various underlying systems may have to be changed based on the area of implementation, such as bus routes and mass parking. Stakeholders with significant security concerns about vehicle-caused pedestrian fatalities stand to benefit most from a total traffic exclusion model.

2. Controlled Traffic Inclusion

Controlled traffic inclusion is a hybrid style of vehicle exclusion in a protected area. Vehicles can be given access to the protected area through one or more access control points. At least a portion of the VSBs in a controlled traffic inclusion model must be active to allow vehicular access. According to CPNI, controlled traffic inclusion can be done in one of two ways: "Scheduled access at times of low risk (i.e., fewer crowds), where the barriers are opened for a period of time during the day or week"[70] and "vehicle entry by exception, where the barriers are only opened for or by authorized (vehicle/ occupants)."[71]

Additional operation and management costs are associated with implementing a hybrid model due to more active VSBs than a in total traffic exclusion model and the need to implement a smart actor in the operation of the VSBs. A controlled traffic inclusion model is most appropriate for pedestrian-rich environments that require protection from vehicle-borne threats but also have regular day-to-day operations such as deliveries and emergency vehicle access.

[69] Centre for the Protection of National Infrastructure, 12.

[70] Centre for the Protection of National Infrastructure, 13.

[71] Centre for the Protection of National Infrastructure, 13.

3. Footway Protection

Footway protection is a hybrid style of vehicle exclusion in a specific area. According to CPNI, it "involves installing passive vehicle security barriers down the entire length of the (pedestrian) footways. It provides a high level of protection to people on the footway whilst allowing the (road) to remain open" to vehicular traffic.[72] Footway protection provides a high level of security against VRAs targeting pedestrians so long as the pedestrians remain within the protective area of the footway. Implementing a footway protection model allows uninterrupted vehicular flow on the roadway while also effectively protecting pedestrians.

Vehicular traffic and pedestrians remain in close proximity under a footway protection plan. By simply being in the immediate vicinity of each other, the likelihood of accidental pedestrian fatalities increases. However, the possibility of an intentional VRA can be significantly reduced in this model is implemented. This type of protection model best suits environments that require continuous vehicular flow but also have concerns over VRAs targeting pedestrians.

4. Traffic Calming

According to the U.S. Federal Highway Administration, "traffic calming reduces automobile speeds or volumes, mainly through the use of physical measures, to improve the quality of life in both residential and commercial areas and increase the safety and comfort of walking and bicycling."[73] A traffic calming model is generally used to create a "mixed-use/partly shared space" between vehicles and pedestrians.[74] Implementing a traffic calming model in a pedestrian-rich environment can reduce the severity of a vehicle-caused pedestrian fatality through the limitation of vehicular speed.

[72] Centre for the Protection of National Infrastructure, 14.

[73] U.S. Department of Transportation Federal Highway Administration, "Traffic Calming EPrimer - Module 2," Safety, February 14, 2017, https://safety.fhwa.dot.gov/speedmgt/ePrimer_modules/module2.cfm#mod21.

[74] Centre for the Protection of National Infrastructure, "HVM Schemes for the Streetscape," 15.

Traffic calming utilizes a variety of horizontal measures to force a vehicle to negotiate turns in order to avoid colliding with an object. Traffic calming utilizes these horizontal measures as opposed to vertical measures, such as speed bumps, in that vertical measures "only slow vehicles driven by consensual drivers."[75] To achieve a successful traffic calming model in an environment, the roadway design must be altered or impact-rated VSBs must be implemented. To help to clarify this model and illustrate methods for implementation, a summary and breakdown of significant traffic calming methods appears in Appendix B. This type of protection model best suits environments that require continuous vehicular flow but also are at risk of VRAs.

I. CONCLUSION

When protecting a pedestrian-rich environment from vehicle-caused pedestrian fatalities and VRAs, there are many risk protection strategies to be considered by stakeholders. Though there is no one-size-fits-all strategy that can be implemented across all environments, stakeholders can tailor their defensive tactics based on their specific circumstances. Individual tactics, such as implementing types of VSBs and engaging in streetscape schemes, are advantageous to the overall defensive-minded practices of target hardening and protective security. Implementing permanent, semi-permanent, and temporary infrastructure all have advantages and disadvantages that must be considered when securing pedestrian-rich environments. There are many options and combinations for stakeholders to choose to best fit their desires, needs, and budgets.

[75] Centre for the Protection of National Infrastructure, 15.

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III. TARGET HARDENING/PROTECTIVE SECURITY SPECTRUM

Urban environments throughout the world are full of targets that stakeholders seek to protect from both intentional and unintentional harm. Adversaries can exploit and attack these targets in many ways. When deciding what to protect from an adversary, the protective security methodology requires a multifaceted and comprehensive approach leveraging as many assets and strengths as possible in order to protect the asset. As such, this comprehensive defense requires the protective actor to implement the five primary principles of protecting an asset from a threat: "deter, detect, delay, mitigate, and respond."[76] A combination of these principles tailored to a specific asset that, "supported by a security plan, will help to frustrate and disrupt an adversary's attack timeline."[77] In this way, protective actors systematically protect assets.

But only three of these five protective principles apply to pedestrians before or during an incident within the scope of this research: deterring, delaying, and mitigating, which CPNI defines as follows:

- deterring: stopping or displacing an attack
- delaying: preventing the attack from reaching the asset
- mitigating: minimizing the consequences of an attack against a site[78]

Protective actors must implement these security principles in an appropriate fashion by using available infrastructure and/or streetscape methods to protect pedestrians from vehicle-caused fatalities within their environments. The manner, amount, and circumstances in which to use these principles depends on the stakeholder's preference and risk tolerance. By using the protective security principles, stakeholders can leverage the strengths of their environments to their advantage.

[76] Centre for the Protection of National Infrastructure, "Protecting Your Assets."

[77] Centre for the Protection of National Infrastructure.

[78] Centre for the Protection of National Infrastructure.

A. TARGET HARDENING CONSIDERATIONS

In essence, target hardening is a general defense-minded practice to protect an asset or location from a threat. According to Fennelly and Perry, target hardening "is the last resort to resist crime by increasing physical security and is a more recognizable, traditional way to discourage crime."[79] They further judge, "target hardening is not a fortress mentality concept; it is a good security practice."[80] Target hardening uses various techniques and strategies ranging from environmental design to "features that prohibit entry or access."[81] Target hardening does not only apply to outdoor assets such as those susceptible to vehicle-caused pedestrian fatalities. But its general concept applies to any asset by implementing any number of "features that prohibit entry or access."[82] The practice of target hardening can readily apply to an elementary school or a hospital as easily as to a military base or government installation. The features needed to harden the target will vary depending on the environment and the level of tolerance possessed by the stakeholders who frequent that environment. A new asset under construction, whether in overall design or applying principles to existing assets by retrofitting them with new infrastructure, qualifies equally as target hardening.

The principles of target hardening and the protective security methodology are homogenous and defense-minded in nature. As such, they can be combined into one model: the target hardening/protective security spectrum (THPSS). Stakeholders can apply this theoretical model to any asset a stakeholder wants to protect. A stakeholder seeking to protect an asset must consistently reevaluate steps taken and measurements implemented by using the THPSS while giving attention to new and emerging trends of nefarious actors. Defenders can implement a dimension of the THPSS that can be utilized on a permanent or temporary basis and in a wide variety of environments.

[79] Fennelly and Perry, CPTED and Traditional Security Countermeasures, 10.

[80] Fennelly and Perry, 10.

[81] Fennelly and Perry, 10.

[82] Fennelly and Perry, 10.

The THPSS can include extensive measures and tactics. This chapter explores three main dimensions of the THPSS regarding the protection of pedestrian-rich environments from vehicle-caused fatalities: the completely open model, the completely hardened model, and the hybrid model. These main dimensions of the spectrum are the most common nationwide and the most easily explained to a layman stakeholder. By considering one of these main dimensions of the THPSS, stakeholders of pedestrian-rich environments can effectively employ critical risk management strategies deemed appropriate given their specific circumstances. Stakeholders can examine one dimension of the THPSS and how it is applied in similar environments in other jurisdictions. After carefully examining and analyzing similar locations, stakeholders can then make an informed decision on how to protect their environments from nefarious actors.

This section explores and defines the three main dimensions of the THPSS and seeks to accomplish this by examining the interventions of permanent, semi-permanent, and temporary infrastructure in various real-world events and environments. By defining THPSS's completely open, completely hardened, and hybrid models, this section seeks to apply the principles of permanent, semi-permanent, and temporary infrastructure explored in Chapter II to real-world scenarios throughout the country.

B. COMPLETELY OPEN MODEL

The completely open model fosters interaction between pedestrians and vehicles. Pedestrians and vehicles are typically near each other with no infrastructure to protect pedestrians from vehicle-caused pedestrian fatalities. In place of infrastructure, stakeholders use various forms of equipment. Under the completely open model, equipment is put in place to discourage vehicular travel in a particular area. However, this equipment typically consists of lightweight metal/wooden barriers or bright-colored, lightweight, and highly visible traffic safety devices such as traffic cones or barrels. This equipment is not impact rated and is predominantly meant to discourage benign vehicle operators from entering the area. This dimension differs from the completely hardened model, which uses no equipment. The lack of permanent barriers creates an environment more susceptible to a deadly vehicle-caused pedestrian fatality.

Designers typically created a streetscape to encourage rapid and efficient vehicular travel with minimal impediments. Though additional safety measures may protect pedestrians such as traffic lights and crosswalks, these measures do little to mitigate the risk of a vehicle-caused pedestrian fatality. Temporary events under the completely open model do not precipitate any change to the streetscape because the location will return to a normally functioning, efficient roadway after the end of the event. Re-engineering the streetscape because of a temporary event will impair the area's ability to maximize this main design feature.

This model implements no traffic calming measures, there is no controlled traffic inclusion, and there is very limited pedestrian pathway protection. The Completely Open model differs from other models because it makes no changes to infrastructure to prevent a vehicle-caused pedestrian fatality of a VRA. Limited utilization of infrastructure and streetscape methods in the completely open model increases the possibility of a vehicle-caused pedestrian fatality or a VRA in this type of environment.

(1) Real World Events

This section lays out two real-world events that employed the THPSS's completely open model.

a. NYC Summer Streets

The NYC Summer Streets program is a "multi-day annual car-free event held in August" in Manhattan spanning from the Brooklyn Bridge to Harlem.[83] NYC Department of Transportation (NYCDOT), in conjunction with the NYC Police Department (NYPD), ensures that traffic is shut down on the affected streets. Positioned with a generally north/south direction flow, the multi-day event encourages pedestrians to attend by allowing an unimpeded pedestrian experience on the street itself. In 2022, the NYC Summer Streets program took place on three separate Saturday mornings in August

[83] New York City Department of Transportation, "Summer Streets," Summer Streets in NYC, 2022, https://www1.nyc.gov/html/dot/summerstreets/html/home/home.shtml.

for six hours from the morning to early afternoon.[84] According to NYC DOT, approximately 300,000 people participate in the NYC Summer Streets program each year to "play, run, walk and bike along Park Avenue and its connecting streets."[85]

This author had a unique perspective of THPSS measures taken during the 2022 NYC Summer Streets program due to his participation both in an official role as a law enforcement officer and in an unofficial role as a patron. It used no VSBs and made no use of the streetscape methods employed throughout any portion of the event. NYC DOT makes no mention of defensive measures to protect the NYC Summer Streets environment and its patrons. There was a limited amount of equipment utilized such as traffic cones and barriers; however, this equipment offered no relief from potential vehicle-caused pedestrian fatalities as it did not meet the VADS standard. Any such equipment that would provide at least some protection to pedestrians, such as blocker vehicles or concrete barriers, was omitted from the defensive measures implemented. Overall, the 2022 NYC Summer Streets program, though uneventful, was at serious risk of a vehicle-caused pedestrian fatality or a VRA.

The NYC Summer Streets program exposes hundreds of thousands of people to the threat of vehicle-caused pedestrian fatalities. Neither NYPD or NYC DOT engage in a small amount of risk mitigation to protect pedestrians at this event. The program occurs in the morning hours with typically much less traffic congestion. Due to this schedule, nefarious actors have an opportunity to operate on relatively unimpeded open roadways, which could allow achieving great vehicular speed before an attack. One can argue that the organizers of the program act recklessly by allowing the program to take place with so few protections.

In its current iteration, NYC should not renew the NYC Summer Streets program in future years without serious reconsideration of proactive risk mitigation measures for pedestrian protection. This event may not be conducive to permanent or semi-permanent VSBs, it could use temporary infrastructure and equipment to better protect pedestrians.

[84] "Summer Streets," New York City Department of Transportation, https://www1.nyc.gov/html/dot/summerstreets/html/route/event-map.shtml.

[85] New York City Department of Transportation.

By engaging in additional reasonable proactive risk mitigation strategies, organizers can better secure the NYC Summer Streets program for pedestrians to enjoy without fear of a deadly vehicle-related incident.

b. San Francisco Sunday Streets

The San Francisco Sunday Streets Program is an "open streets program that transforms city streets into car-free community spaces for pedestrians to enjoy."[86] The event started in 2008 and its "routes are 1–4 miles in length" and serve "100,000 residents."[87] The most recent iteration of the program, from early spring to mid-fall in 2022, sponsored car-free events once a month in various locations throughout San Francisco.[88] Though the event takes place in different areas and has different emphases based on the locations in which it is managed, each individual event possesses unique streetscape features.

There do not appear to be any significant mitigation measures enacted to protect program patrons from VRAs or deadly vehicle versus pedestrian collisions. According to the organizers of the San Francisco Sunday Streets Program, it is possible for vehicles belonging to "businesses and neighbors" to access the specific route of the program's event.[89] There do not appear to be any hard shutdowns of vehicular traffic in the area through traffic management, VSBs, streetscape techniques, or equipment. The sole mitigation measure appears to be the mere presence of traffic enforcement officers and volunteers to ensure "a smooth experience."[90] If some innocuous vehicles gained access to the pedestrian-rich environment, nefarious actors could do the same.

The Sunday Streets San Francisco program must be dramatically reduced in scale. The program should take place in only one or a handful of different locations. The

[86] "Sunday Streets Is Back, San Francisco!," Sunday Streets SF, 2022, https://www.sundaystreetssf.com/.

[87] "About," Sunday Streets SF, 2022, https://www.sundaystreetssf.com/about/.

[88] "Sunday Streets SF," 2022, https://www.sundaystreetssf.com/wp-content/uploads/2022/05/2022_PRINT8.5x11_SundayStreets.pdf.

[89] Sunday Streets SF, "About."

[90] Sunday Streets SF.

locations chosen to host the program should currently possess streetscape features to protect pedestrians or accommodate temporary VSBs during the course of the event. Additionally, to remove the risk of a vehicle-caused pedestrian fatality, no vehicles should enter inside the pedestrian-rich environment. A public information campaign should also be established to make affected communities aware of these details. These minor policy changes will create a more secure environment for pedestrians while simultaneously allowing pedestrians to enjoy an outdoor car-free space.

C. COMPLETELY HARDENED MODEL

The completely hardened model exists where there is overt discouragement of interaction between pedestrians and most vehicles. Depending on the location, some completely hardened models prohibit all vehicles from coming within proximity of pedestrians while others allow authorized emergency or prescreened vehicles. Unlike the completely open model, the completely hardened model features a heavy amount of infrastructure to protect pedestrians from collisions and VRAs in this type of environment. It usually uses permanent or semi-permanent infrastructure. The completely hardened model primarily appears in permanent environments considered soft targets.

This environment designs the streetscape to discourage vehicular travel in the area to promote pedestrian safety rather than rapid and efficient vehicular travel. This is accomplished through measures such as permanent VSB infrastructure and total traffic exclusion. These additional safety measures significantly mitigate the risk of a vehicle-caused pedestrian fatality or a VRA through their design. Other streetscape measures used under this model including traffic calming measures and pedestrian pathway protection. Though the completely hardened model halts vehicles, pedestrian travel can remain relatively unimpeded if desired by the stakeholders.

Given that nefarious actors can exploit equipment, the completely hardened model does not use it, differing from the completely open model. Given that this model overtly discourages interaction between vehicles and pedestrians, lightweight equipment in this type of dimension of the THPSS has no place. Any use of lightweight equipment

would hinder an environment's ability to discourage interaction between pedestrians and vehicles.

(1) Real -World Location

This section lays out one real-world location that uses the completely hardened model of the THPSS.

NYC: World Trade Center Site

The WTC site was an internationally known location prior to the September 11 terror attacks and has become even more recognizable since then. It is approximately 19 acres consisting of several new high-rise structures, retail space, and a dedicated NYPD command.[91] It is a major tourist attraction and more than eight million tourists come annually to reflect, pay their respects, and mourn.[92] Given the site's notoriety and the number of pedestrians who frequent the area on a daily basis, the WTC site is a pedestrian-rich environment.

Several defensive measures have been implemented throughout the new WTC site. Permanent bollards surround areas in which pedestrians gather. Within the perimeter of the bollards, trees have been planted and street furniture has been installed, giving the site a more aesthetically pleasing look. However, in the unlikely event that the bollards fail, this infrastructure serves as an effective backup. The implementation of these defensive measures has eliminated the threat of a VRA from occurring within the WTC site.

The WTC area does remain a large commercial area with commercial shopping establishments, hotels, and offices. As such, some vehicle traffic is necessary to ensure the continual operation of these establishments. To limit the risk of a VRA or a deadly vehicle versus pedestrian collision, permanent VSBs allowing controlled traffic inclusion

[91] CommercialCafe, "Office Building of The Week: One World Trade Center, NYC," CommercialCafe, November 6, 2018, https://www.commercialcafe.com/blog/office-building-week-one-world-trade-center-nyc/.

[92] Brian Pascus, "National 9/11 Memorial and Museum Sees Visitor Rebound," Crain's New York Business, September 9, 2002, https://www.crainsnewyork.com/hospitality-tourism/national-911-memorial-and-museum-sees-tourists-returning-new-york-city.

have been included in the design of the area. These features have proven effective in that there has not been a vehicle-caused pedestrian fatality or a VRA at the WTC site since its inception. Figure 4 is a photograph of a permanent VSB designed to permit controlled traffic inclusion.

Figure 4. Permanent VSB Near the WTC Site

Although the WTC site design has effectively prevented VRAs and deadly vehicle versus pedestrian collisions, much of the area surrounding the WTC site remains under construction over 20 years after the destruction of the original WTC. Those responsible for the overall design of the surrounding area should prudently include various defensive streetscape methods in this new construction. These streetscape methods have proven effective in the area and will lower the risk of a VRA or deadly vehicle versus pedestrian collision from occurring.

D. HYBRID MODEL

The hybrid model allows some interaction between pedestrians and vehicles. Depending on the location, some areas permit vehicles and pedestrians to come close to each other and others may have completely separate pedestrian and vehicle areas. Typically, at least some amount of infrastructure implemented and designed to protect pedestrians from collisions and VRAs appears in this type of environment. The infrastructure used in the hybrid model can either be permanent, semi-permanent, or temporary and may change with the conditions in the environment.

Environments that employ the hybrid model can encompass a wide array of circumstances. These may include high-profile temporary events, non-permanent events that last for an extended period, and environments in which stakeholders feel that they can best limit the impact, severity, and likelihood of VRAs and vehicle versus pedestrian collisions. Stakeholders hold distinct advantages when using the hybrid model as they can tailor the tactics employed to their specific environments.

Similar to the completely open model, the streetscape that typically accompanies the hybrid model encourages rapid and efficient vehicular travel as opposed to pedestrian safety. However, its infrastructure typically follows the overall design phase to protect pedestrians. As with the completely hardened model, pedestrian travel remains relatively unimpeded. In some circumstances in the hybrid model, equipment can be employed to separate vehicles and pedestrians. Essentially, a typical hybrid model environment adopts aspects of completely hardened and completely open models to best fit the needs of stakeholders.

Stakeholders must exercise due care when choosing when and where to place various forms of equipment in the hybrid model because it does not necessarily deter nefarious actors. Placing equipment at vehicle entry and exit points in a pedestrian-rich environment, for example, may serve to prevent accidental vehicle-caused pedestrian fatalities within such an environment. However, this placement of equipment would do nothing to prevent a VRA. An approach encompassing a risk model can be advantageous when considering equipment. This model differs from the completely hardened model

that uses no equipment. Ultimately, the respective stakeholders must tailor the tactics and measures implemented within a hybrid model environment to best fit their environment.

(1) Real World Events

This section lays out two real-world events that used the THPSS hybrid model.

b. Holiday Open Streets Program

Rockefeller Center displays its Christmas tree every year from the first Wednesday after Thanksgiving until early January. The world-renowned Rockefeller Center Christmas Tree (RCCT) draws millions of tourists into Midtown Manhattan for entertainment, shopping, and dining. Such an influx of pedestrians into a confined area is an attractive target for a VRA and presents a significant risk of a deadly vehicle versus pedestrian collision in this well-known pedestrian-rich environment.

For the 2022/2023 Christmas season, NYC DOT implemented a new traffic setup in the vicinity of the RCCT, called the Holiday Open Streets program. NYC DOT closed 5th Avenue, a five-lane major arterial road running in a southerly direction, to vehicles on three separate Sundays in December. NYC DOT and the NYPD shut down all southbound traffic spanning 11 city blocks in the vicinity of the RCCT.[93] The city implemented the program in an effort to "ease crowding (facilitate) access to the iconic holiday window displays and creating a more pleasant holiday environment for New Yorkers and visitors, while enhancing public safety for all."[94] By installing blocker vehicles and concrete barriers, NYC DOT and the NYPD's Counterterrorism Bureau (CTB) have effectively created a hybrid environment in which a VRA or a deadly vehicle versus pedestrians collision is much less likely to occur. Figure 5 shows the general layout of the Holiday Open Streets program.

[93] NYC Office of the Mayor, "Mayor Adams Unveils Sweeping Plan for Holiday Season Car-Free Open Streets in Midtown Manhattan," The official website of the City of New York, November 22, 2022, http://www1.nyc.gov/office-of-the-mayor/news/859-22/mayor-adams-sweeping-plan-holiday-season-car-free-open-streets-midtown-manhattan-.

[94] NYC Office of the Mayor.

Figure 5. NYC Holiday Open Streets Program, 2022–2023

In an effort to limit the amount of traffic congestion, both east and westbound traffic remained unimpeded in the area. By implementing this traffic pattern, countless vehicles can traverse 5th Avenue, cutting through the seemingly endless crowd of pedestrians. Though it would be difficult for a vehicle to penetrate the blocker vehicles and concrete barriers and proceed onto 5th Avenue, the possibility of a VRA or deadly vehicle versus pedestrian collision still exists within the 10 intersections that encompass the Holiday Open Streets program**.** The considerable number of distracted pedestrians who are immersed by the various Christmas displays and other attractions in the area makes it even more necessary to shut down these intersections of east and westbound traffic in future years regardless of the effect on traffic congestion.

c. The 126th Boston Marathon

The 126th Boston Marathon took place on April 18, 2022.[95] Starting in Hopkinton, MA, and culminating on Boylston Street in downtown Boston, 24,918 total runners competed on the route that spanned 26.2 miles through the suburbs of Boston.[96] The influx of such a mass number of pedestrians can strain the resources of local government agencies and creates an attractive target for nefarious actors due to the population, media coverage, and historical relevance. The thousands of participants combined with the thousands of spectators flooding the greater Boston area on what is commonly known as Patriot's Day creates a massive temporary pedestrian-rich environment.

This author had a unique perspective of THPSS measures taken during the 2022 Boston Marathon due to his participation in the event. Iconic locations throughout the course had large amounts of temporary infrastructure and equipment for pedestrian protection, whereas other locations were much more open to allow spectator involvement. Due to the relatively brief duration of the event, stakeholders could not implement permanent VSBs or major streetscape methods throughout the course.

[95] "Marathon Dates," Boston Athletic Association, 2021, https://www.baa.org/races/boston-marathon/plan/marathon-dates.

[96] "126th Boston Marathon Post-Race Stats and Storylines," Boston Athletic Association, 2021, https://www.baa.org/126th-boston-marathon-post-race-stats-and-storylines.

However, organizers used the temporary infrastructure and equipment effectively. In the outskirts of Boston, temporary infrastructure was deployed into areas in which the streetscape environment allowed vehicles easy access to the marathon route. This greatly reduced the risk of a VRA along the marathon route. The protective measures taken also allowed for a seamless transition to open streets at the conclusion of the event.

Various agencies such as the Boston Police Department, the Massachusetts State Police, and the Federal Bureau of Investigation all appeared to work collaboratively to ensure a smooth and uneventful Patriot's Day in the greater Boston area. Though this author did notice that some parts of the race route and the spectator areas were open to a threat, most areas reflected the hybrid model philosophy and, with a few minor tactical changes, future iterations of the Boston Marathon could further improve them.

E. CONCLUSION

The THPSS provides a valuable theoretical framework in which stakeholders can analyze their respective environments and consider how to best protect them with consideration of their unique assets and constraints. The chapter illustrates the use of the THPSS to analyze how to best secure temporary small-scale events such as the NYC Summer Streets program, permanent locations such as the WTC site, and high-profile events such as the 126th Boston Marathon. Given the spectrum's ability to frame a wide range of environments and circumstances, outdoor environments within NYC can undoubtedly apply it to better protect pedestrians. No two outdoor environments are completely alike, whether comparing environments within a limited geographical distance or at a wide-ranging national level. As such, the THPSS framework and its wide-ranging diversity of protective abilities can be an effective tool in which stakeholders can defend their respective environments.

Permanent, semi-permanent, and temporary infrastructure all have roles within THPSS. Under the THPSS philosophy, the designation of an environment as either completely open, completely hardened, or hybrid will largely depend on the types of infrastructure utilized within that environment. By considering the unique features of

their environment, stakeholders can then implement the appropriate type of infrastructure to protect pedestrians from vehicle-borne threats.

Within NYC, pedestrians frequent dozens of neighborhoods that provide different types of outdoor environments. Each outdoor environment possesses varying degrees of infrastructure, different streetscape features, and abilities to deter, delay, and mitigate vehicle-related collisions and terror attacks.[97] Given the wide array of strengths and vulnerabilities of each outdoor environment, no "one-size-fits-all" approach or design can protect pedestrian. Given this reality, the THPSS provides an effective theoretical framework for the overall protection of outdoor environments both within NYC and other locations nationwide.

[97] Centre for the Protection of National Infrastructure, "Protecting Your Assets."

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IV. CONCLUSIONS AND RECOMMENDATIONS

NYC is home to countless events and locations of varying sizes that are considered soft targets. Though events and locations such as the NYC Marathon and the WTC site are often at the forefront of media coverage and have widespread attention, other pedestrian-rich environments such as outdoor dining and greenspaces are often overlooked and are left significantly unprotected from an attack. If NYC leadership and policymakers are going to encourage people to visit outdoor environments, adequate protection of these environments must be a top priority. By considering low-profile/soft targets through the lens of the THPSS, this chapter identifies and considers areas in need of improvement. By embracing these policy recommendations, NYC will be better equipped to protect pedestrians from vehicle-caused pedestrian fatalities and VRAs in these overlooked environments.

This thesis also detailed current infrastructure, the rating systems and standards of current infrastructure, and the streetscape methodology. The THPSS methodology provides an opportunity for both private sector and Homeland Security practitioners to examine their own environments, regardless of size or population, and better protect pedestrians within those targets from deliberate and non-deliberate threats. This chapter presents examples of pedestrian-rich environments in which the THPSS methodology should be leveraged to better protect such environments from vehicle-caused pedestrian fatalities and VRAs.

A. OUTDOOR DINING

The phenomenon of outdoor dining has drastically increased throughout the United States since the outbreak of COVID-19. In New York City, for example, outdoor dining has not simply been limited to a few tables and chairs placed on the sidewalk of an established eatery. Rather, the city is in the process of implementing the Permanent Open Restaurants program in 2023. According to NYC DOT, the program is being implemented "to allow restaurants to use the sidewalk adjacent and curbside roadway

space in front of their businesses for outdoor dining."[98] As outdoor dining continues to endure and expand, the risk of a vehicle-caused pedestrian fatality or a VRA in such an environment has also heightened.

NYC DOT, the official manager of the Permanent Open Restaurants program, does not mention the risk of, nor any mitigation against, a vehicle-caused pedestrian fatality or a VRA explicitly.[99] Instead, NYC DOT implicitly suggests there is an increased risk of vehicular collisions with pedestrians in outdoor dining environments simply because of the close proximity of the outdoor dining patrons to vehicular traffic. This is illustrated by the lack of infrastructure, the use of the equipment, and simple reflection tape for visibility. Figure 6 contains is a generic blueprint of an outdoor dining environment provided by the NYC DOT.

[98] New York City Department of Transportation, "Open Restaurants," Pedestrians, accessed October 20, 2022, https://www1.nyc.gov/html/dot/html/pedestrians/openrestaurants.shtml.

[99] New York City Department of Transportation.

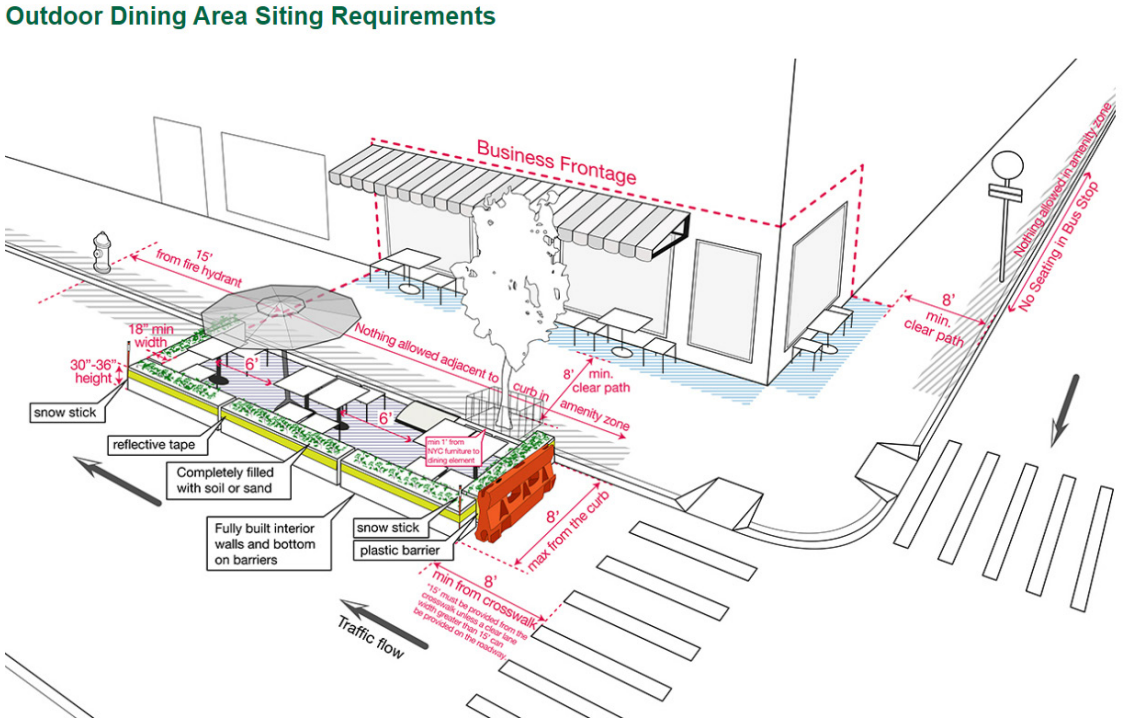

Figure 6. Blueprint of Outdoor Dining Environment[100]

Prior to implementing a permanent outdoor dining program in any location, program managers should consider the risk of a vehicle-caused pedestrian fatality or a VRA. Program managers must also mandate measures to mitigate the risk of such an incident. If mitigation measures are deemed too costly or otherwise not able to be feasibly implemented, a permanent outdoor dining program should not be administered.

B. STREET FAIRS

Street fairs have existed in urban areas throughout the United States for decades. The geographic size and the number of patrons can vary. In NYC, for example, the annual Feast of San Gennaro is a widely popular street fair spanning a large geographic area. There are also smaller single-day street fairs covering only a few blocks on local streets in Manhattan such as Broadway and 9th Avenue. Street fairs typically consist of temporary vendor tents with various shopping and food attractions. Street fairs are unique in that they are planned in advance and take place on permanent roadways. Street fairs

[100] Source: New York City Department of Transportation.

take place on local roads closed to vehicular traffic; the larger the area a street fair encompasses, the more access points a potential nefarious actor can exploit.

If stakeholders wish to continue operating and attending street fairs, they must give specific consideration to VRAs. The use of the THPSS methodology can be applied to protecting street fair patrons from VRAs. However, the risk of a VRA may vary from one environment to another. By utilizing the methodology, stakeholders can implement the appropriate protective measures necessary to effectively harden their specific environment from attack. For example, the stakeholders of the Feast of San Gennaro may consider semi-permanent VADS-based infrastructure to protect their patrons whereas a smaller festival in a less populated area may simply utilize blocker vehicles. Stakeholders must leverage their specific knowledge and expertise of their respective environments coupled with the THPSS methodology to come up with a way to reasonably protect their environments from attack.

C. NYC OPEN STREETS PROGRAM

According to the NYC DOT, the NYC Open Streets program "transforms streets into public space open for all."[101] The program has three separate components: limited local access, full closure, and full closure: schools.[102] Depending on the component, a street can either engage in controlled traffic inclusion or a full shutdown of vehicular traffic. The purpose of the program is to control crowding by allowing pedestrians additional space by implementing some sort of vehicular exclusion.

NYC DOT welcomes stakeholders to apply for an "Open Street in their community," however, the program appears to have limited means to deny the application for an Open Street.[103] Though there are stipulations as to what time of day an Open Street can be implemented, the only tangible exception is that an Open Street "may

[101] New York City Department of Transportation, "Open Streets."

[102] "NYC Open Streets," New York City Department of Transportation, accessed October 24, 2022, https://www1.nyc.gov/html/dot/downloads/pdf/open-streets-overview.pdf.

[103] New York City Department of Transportation, "Open Streets."

not occur along a bus or truck route."[104] Additionally, the types of locations that have already been approved for an Open Street are wide-ranging in that they include commercial, residential, mixed-use, and other types of environments. NYC DOT appears to implicitly encourage Open Streets throughout the city without giving much consideration to potential hazards.

NYC DOT also does not appear to be taking into consideration the possibility of a VRA when approving applications for an Open Street. NYC DOT describes how a "typical setup" of an Open Street will appear after it has been implemented (Figure 7).[105] Each description does not address streetscape measures or possible infrastructure placement. Rather, an image of a generic street with equipment and signage saying "Do Not Enter" is provided.[106] Both consideration of and mitigation against a VRA are not mentioned. By ignoring this potentially deadly threat, NYC DOT is acting in a negligent manner through the widespread implementation of the Open Streets program.

[104] New York City Department of Transportation, "Open Streets Program 2022 Application," Program Overview, accessed October 25, 2022, https://www.nyc.gov/html/dot/html/pedestrians/openstreets.shtml#apply.

[105] New York City Department of Transportation, "Open Streets."

[106] New York City Department of Transportation.

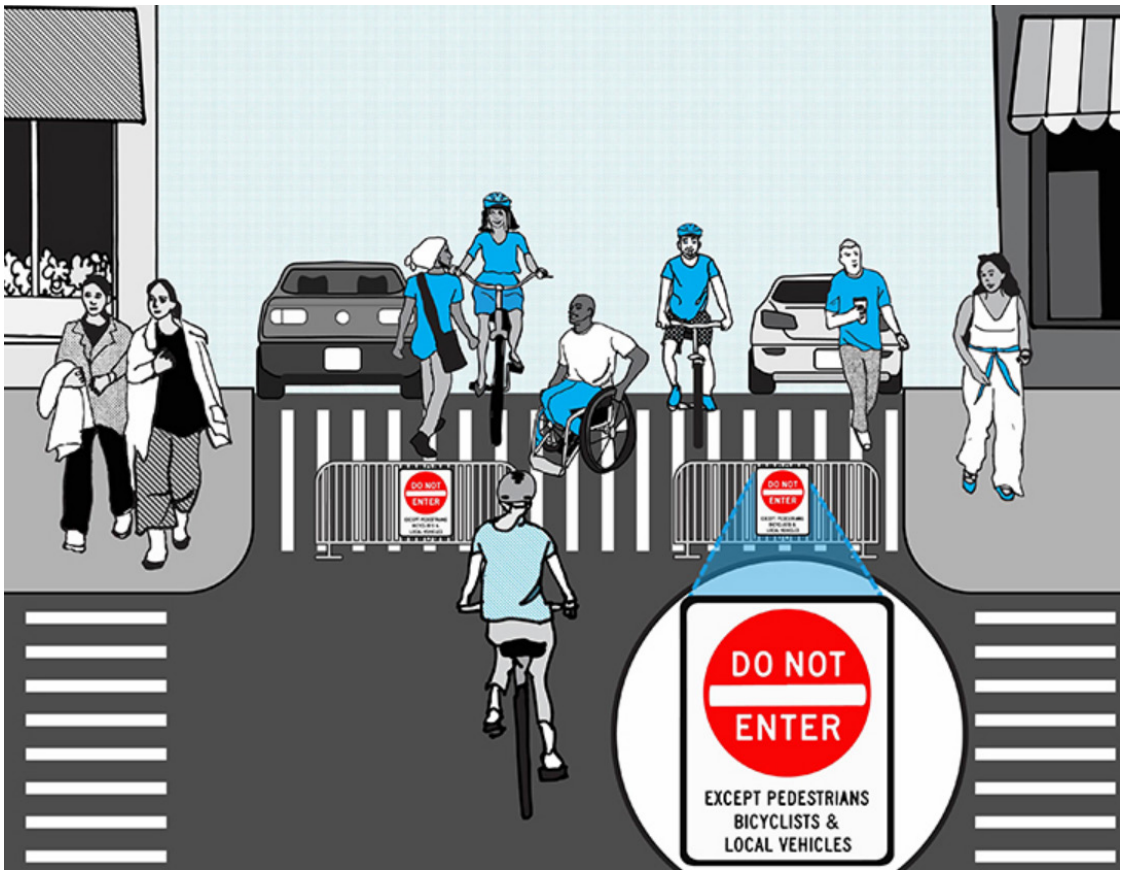

Figure 7. NYC DOT's Typical Setup of an Open Street[107]

The entire Open Streets program in NYC needs to be either eliminated or significantly changed. If the program is to remain operational, NYC DOT must consider streetscape measures and other mechanisms to both prevent and mitigate the threat of a VRA. By allowing Open Streets to be implemented in nearly any area, the risk of a VRA increases exponentially. Before approving a specific location to be an Open Street, representatives from NYC DOT and the NYPD's CTB should inspect the area for its feasibility to withstand such an attack. Characteristics of an environment to be considered include any streetscape measures that have already been applied and the feasibility to implement infrastructure or further streetscape techniques. If these actions are not practical, the Open Streets program should be completely eliminated as the risk of a VRA outweighs the reward of any singular street closed to traffic for pedestrian enjoyment.

[107] Source: New York City Department of Transportation, "Open Streets."

D. ROAD RACES

Road races occur throughout the year in all areas of the country. Road aces span distances from as little as a mile to as much as a marathon and are incredibly popular drawing in numerous competitors, volunteers, and spectators. The number of pedestrians patronizing a road race can vary depending on the race's popularity. Large races such as the Boston and NYC Marathons boast tens of thousands of competitors alone, whereas other road races in smaller jurisdictions may only boast a few dozen. Similar to street fairs, road races are planned well in advance and take place on permanent roadways. A single road race can possess thousands of access points that a nefarious actor can exploit. For example, the annual 5th Avenue Mile, which takes place on Manhattan's Upper East Side, encompasses 28 individual access points in which a VRA can originate. Though it may be feasible for stakeholders to secure a road race that only stretches a single mile, it becomes increasingly difficult to do so as the distance of a road race increases.

Small road races, such as those that have limited participation and take place in smaller communities, likely will not find the use of the THPSS methodology particularly useful. These types of road races typically encompass shorter distances with limited popularity compared to larger races. Small road races usually conclude within a matter of minutes. As such, the resources necessary to effectively plan and implement mitigation measures through the lens of the THPSS may exceed the level of risk of a VRA in such an environment. However, the possibility of a deadly vehicle versus pedestrian collision remains, particularly if the route is open to vehicular traffic. Stakeholders may opt for a more fluid approach to protecting these types of events through means such as rolling street closures and lead and rear-blocking vehicles. Though the THPSS methodology may be impractical in small road races, stakeholders must nonetheless recognize and respect the risk of a vehicle-caused pedestrian fatality or a VRA in their particular environment.

Stakeholders of large road races must be heedful of the threat of a VRA. Large road races represent an opportunity for nefarious actors to not only engage in a deadly terror attack but also use an attack on such an event for propaganda purposes. The use of the THPSS methodology can be applied to protecting pedestrians at a large road race. By utilizing the methodology, stakeholders can implement the appropriate protective

measures necessary to effectively harden their specific environment from attack. Stakeholders may also consider implementing separate aspects of the THPSS methodology in different areas of their environment. For example, organizers of the NYC Marathon may consider implementing a hybrid model approach to include VADS-based infrastructure along the route at intersections close to limited-access highways but utilize a completely hardened model in the high-profile start and finish areas. Stakeholders of large road races must utilize their specific knowledge of their respective events with the THPSS methodology to come up with a practical way to protect their events from a large-scale attack.

E. URBAN PUBLIC PARKS

For decades, urban public parks have remained largely unchanged as countless pedestrians use them to escape the constant flurry of commotion that goes hand in hand with urban living. Though most urban public parks exclude vehicular traffic, other urban public parks allow vehicles on a limited basis due to their size and geographical location within an urban area. If vehicles are allowed to operate within urban parks, there is a possibility of a vehicle-caused pedestrian fatality or a VRA.

There are some urban public parks that allow a large number of vehicles to travel within their respective perimeters. NYC's Central Park and San Francisco's Golden Gate Park are two such examples that allow vehicular access in specific areas. Going into greater detail, NYC limits vehicles from traveling inside Central Park except for a few designated areas specifically designed to accommodate them. These areas, such as the 79th Street transverse, have been implemented in areas to best alleviate area traffic congestion. These roadways, which have been designed as an underpass, do not allow pedestrians and effectively limit the possibility of a deadly incident involving a pedestrian to nearly zero. It is possible to both ease vehicular congestion in the area and limit the risk of pedestrian fatalities in large urban parks by having these sorts of design features.

Large urban parks have been designed in a welcoming manner with gaps in perimeter walls to invite numerous pedestrians. Gaps in the perimeter of a park create an

avenue that nefarious actors can exploit. Two large parks within NYC, Manhattan's Central Park and Brooklyn's Prospect Park, have several paved gaps along their respective perimeters. These gaps encompass no infrastructure to prevent an attack. Rather, signage and equipment have been casually placed at these gaps to discourage innocuous drivers from entering the area. The use of semi-permanent infrastructure or a controlled traffic inclusion model would significantly mitigate the risk of an attack in these situations. Such a model, though costly, can be fiscally justified by large municipalities. Stakeholders of large urban parks should survey their respective environments for gaps in perimeter walls and implement measures at these gaps to mitigate VRAs from occurring within park boundaries.

F. CONCLUSIONS

This thesis has identified several measures to better secure pedestrian-rich environments by utilizing the THPSS. When effectively utilized, the THPSS provides a valuable theoretical framework stakeholders can utilize to protect many types of soft targets in addition to pedestrian-rich environments. Ultimately, those tasked with or responsible for the protection of a soft target must educate themselves on emerging trends and tactics that nefarious actors may utilize to attack the innocent. With knowledge of potentially deadly scenarios coupled with intimate familiarity with their local environments, stakeholders are able to employ an effective defensive strategy to mitigate the risk of a vehicle-caused pedestrian fatality or a VRA in their area of operation. NYC and other municipalities have the capability to better protect these environments from vehicular threats.

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APPENDIX A. IMPACT-RATED TEST METHODS/STANDARDS

A. ISO IWA 14-1:2013

According to ATG Access, a manufacturer of various VSBs, "IWA stands for 'International Workshop Agreement' and is overseen by the International Organization for Standardization (ISO)."[108] ISO IWA 14-1:2013 "specifies the essential impact performance requirement for a vehicle security barrier (VSB) and a test method for rating its performance when subjected to a single impact by a test vehicle not driven by a human being."[109] Unlike other testing standards, ISO IWA 14-1:2013 does not include data related to debris dispersal immediately after an impact.

To read the performance rating of a VSB tested to the ISO IWA 14-1:2013 standard, the reader must have appropriate context to understand how the code is exhibited.

Sample ISO IWA 14-1:2013 Rating: V / 1500 [M1] / 48 / 90 / 1.0

In the sample rating, "V" indicates the test included a "vehicle impact."[110]

In the sample rating, "1500 [M1]" indicates the type of vehicle used in the test. "1500" indicates the mass of the vehicle used in kilograms and "[M1]" is the corresponding vehicle classification.[111] The vehicle classifications used in the ISO IWA 14-1:2013 appear in Table 1.

[108] Edward Roberts, "What Is IWA 14? The Definitive Guide to IWA 14-1," ATG Access, January 28, 2021, https://www.atgaccess.com/news/guides/what-is-iwa-14.

[109] iTeh Standards, "IWA 14-1:2013 - Vehicle Security Barriers — Part 1: Performance Requirement, Vehicle Impact Test Method and Performance Rating," iTeh Standards Store, November 14, 2013, https://standards.iteh.ai/catalog/standards/iso/354777ba-e2c9-44d0-ac10-d5a345361763/iwa-14-1-2013.

[110] Centre for the Protection of National Infrastructure, "Impact Testing of Vehicle Security Barriers," 10.

[111] Roberts, "What Is IWA 14?"

Table 1. Vehicle Classifications for ISO IWA 14-1:2013[112]

Mass (kg)	Vehicle Classification	Vehicle Type
1500kg	[M1]	Car
2500kg	[N1G]	4x4 crew or single cab pick-up
3500kg	[N1]	Flat bed
7200kg	[N2A]	Day cab
7200kg	[N2B]	Day cab
7200kg	[N3C]	Day cab
12000kg	[N3D]	Day cab
24000kg	[N3E]	Day cab
30000kg	[N3F]	Day cab

In the sample rating, "48" indicates the "speed in kilometres per hour (KPH) that the vehicle was travelling at for the test."[113] For this standard, the speed tested varies between 16 and 122 KPH.[114]

In the sample rating, the "90" represents the angle at which the vehicle impacted.[115]

"1.0" represents the distance in meters in which the "load-carrying part of the vehicle traveled past the VSB datum line."[116]

B. BSI PAS 68

BSI PAS 68 is sometimes referred to as BSI PAS 68:2013, indicating that 2013 is the year in which the most recent standard was implemented. It can simply be referred to

[112] Adapted from Centre for the Protection of National Infrastructure, "HVM - Impact Rated - Rating System Explained."

[113] Roberts, "What Is IWA 14?"

[114] Roberts.

[115] Centre for the Protection of National Infrastructure, "Impact Testing of Vehicle Security Barriers," 10.

[116] Roberts, "What Is IWA 14?"

as PAS 68.[117] According to ATG Access, "PAS 68 is a publicly available specification (PAS) for impact testing and rating hostile vehicle mitigation products such as bollards, blockers and barriers used for security and counter-terrorism purposes."[118] A key data measurement BSI PAS 68 accounts for is debris dispersal after an impact.

To read the performance rating of a VSB tested to the ISO IWA 14-1:2013 standard, the reader must have appropriate context to understand how the code is exhibited.

Sample BSI PAS 68 Rating: V / 1500 [M1] / 48 / 90 : 0/1

In the sample rating, "V" indicates the test for the product included the use of a vehicle.[119] Other, less common, methods of testing include "D" for design during a simulated test and "P" for pendulum during a low energy test.[120]

In the sample rating, "1500 [M1]" indicates the type of vehicle used in the test. "1500" indicates the mass of the vehicle used in kilograms and "[M1]" is the corresponding vehicle classification.[121] The vehicle classifications used in the BSI PAS 68 are detailed in Table 2.

[117] Edward Roberts, "What Is PAS 68? The Definitive Guide To BSI PAS 68," ATG Access, December 14, 2020, https://www.atgaccess.com/news/guides/what-is-pas-68.

[118] Roberts.

[119] Roberts.

[120] TISO, "Guide to PAS 68:2013," accessed July 18, 2022, https://tiso-blockers.com/news/472-guide-to-pas-68-2013-standard.

[121] Roberts, "What Is PAS 68?"

Table 2. Vehicle Classifications for BSI PAS 68[122]

Mass (kg)	Vehicle Classification	Vehicle Type
1500kg	[M1]	Car
2500kg	[N1G]	4x4 crew or single cab pick-up
3500kg	[N1]	Flat bed
7500kg	[N2]	Day cab
7500kg	[N3]	Day cab
30000kg	[N3]	Day cab

In the sample rating, "48" represents the test speed "measured in kilometers per hour (kph)."[123]

In the sample rating, "90" represents the impact angle of the test, which is typically 90 degrees.[124]

In the sample rating, "0" represents the distance in meters in which the "load-carrying part of the test vehicle traveled the back face of the product being tested before being drawn to a complete stop."[125]

In the sample rating, "1" represents the furthest point that debris weighing over 25kg traveled, in meters, during the test.[126]

C. CEN CWA 16221:2010

According to the CPNI, this test method has been withdrawn as of 2018.[127]

[122] Adapted from Centre for the Protection of National Infrastructure, "HVM - Impact Rated - Rating System Explained."

[123] Roberts.

[124] TISO, "Guide to PAS 68:2013."

[125] Roberts, "What Is PAS 68?"

[126] Roberts.

[127] Centre for the Protection of National Infrastructure, "Impact Testing of Vehicle Security Barriers."

D. BSI PAS 170-1:2017

According to ATG Access, BSI PAS stands for the British Standards Institution Publicly Available Specification.[128] Released in 2017, BSI PAS 170–1:2017 is a lesser-known rating standard that is not intended to replace ISO IWA 14-1:2013 or BSI PAS 68, but rather to provide soft targets such as "car parks, schools and retail outlets with a certain level of impact tested security" in the event of a low-speed passenger vehicle impact.[129] This testing standard only has one type of vehicle that is utilized in the test and is meant to replicate a 4x4 vehicle.[130] Similar to the ISO IWA 14-1:2013 standard, it does not account for debris dispersal after an impact.

To read the performance rating of a VSB tested to the BSI PAS 170–1:2017 standard, the reader must have appropriate context to understand how the code is exhibited.

Sample BSI PAS 170-1:2017 Rating: IT / 2500 / 16 / 90 / 0.0

In the sample rating, "IT" stands for Impact Trolly and is the "only type of test method used.[131] This is different from the ISO IWA 14-1:2013 or BSI PAS 68 standards which utilize multiple types of vehicles during testing.

In the sample rating, "2500" represents the weight of the Impact Trolly in kilograms.[132] For the BSI PAS 170–1:2017 standard, 2500kg is consistent throughout all tests.[133]

[128] Edward Roberts, "What Is PAS 170? The Definitive Guide," ATG Access, January 28, 2021, https://www.atgaccess.com/news/guides/what-is-pas-170.

[129] Roberts.

[130] Centre for the Protection of National Infrastructure, "Impact Testing of Vehicle Security Barriers," 12.

[131] Roberts, "What Is PAS 170?"

[132] Roberts.

[133] Roberts.

In the sample rating, "16" represents the speed in kilometers per hour of the Impact Trolly during testing.[134] For the BSI PAS 170–1:2017 standard, the speed of the test can only be either 16KPH or 32KPH.[135]

In the sample rating, "90" represents the angle of impact.[136]

In the sample rating, "0.0" represents the penetration distance, in meters, of the Impact Trolly "beyond the product's datum line."[137] If the penetration distance exceeds 2 meters, then no rating is issued to the product.[138]

[134] Roberts.

[135] Roberts.

[136] Roberts.

[137] Roberts.

[138] Roberts.

APPENDIX B. SIGNIFICANT TRAFFIC CALMING METHODS

A. LANE NARROWING/LANE REMOVAL

Certain streets are designed with multiple lanes to increase traffic flow and prevent traffic congestion. By re-engineering a street to retain fewer lanes, the amount of congestion can be increased to a tolerable level that will also force a hostile vehicle to reduce its speed based on traffic conditions. The space of the reduced lane would then be allocated to a different function. According to the NYC DOT, these techniques can "have powerful traffic calming benefits."[139] Alternative functions of the removed lane can range from "pedestrian safety islands, expanded pedestrian space, on-street or separated bike lanes, parking, or other functions."[140]

B. CHICANES

According to Hess and Sneha, a chicane is an artificial "physical design element (intended) to slow down motor vehicles and increase pedestrian safety" by forcing a vehicle to engage in a serpentine which will reduce its speed.[141] According to the NYC DOT, a chicane is "a series of narrowings or curb extensions that alternate from one side of the street to the other forming S-shaped curves to slow traffic."[142] These artificial curves can be implemented in numerous ways such as parking conditions, pedestrian relief areas, or infrastructure. By implementing chicanes and preventing vehicles from traveling in a straight line, the speed at which a vehicle can travel is then reduced based on the distance between the chicanes.

C. GEOMETRIC ROADWAY DESIGN

According to the Institute of Transportation Engineers, "geometric design refers to the dimensions and arrangements of the visible features of a roadway. This includes

[139] "Traffic Calming," New York City Department of Transportation, accessed July 19, 2022, https://www.nycstreetdesign.info/geometry/traffic-calming.

[140] New York City Department of Transportation.

[141] Hess and Mandhan, "Ramming Attacks, Pedestrians, and the Securitization," 6.

[142] New York City Department of Transportation, "Traffic Calming."

pavement widths, horizontal and vertical alignment, slopes channelization, intersections and other features that can significantly affect the operations, safety and capacity of the roadway network."[143] Implementing these geometric design techniques hinders a hostile vehicle from reaching a high rate of speed before an attack. According to CISA, by effectively reducing the rate of speed a hostile vehicle is able to attain before an attack by using geometric design techniques, the "level of performance required for the" VSB to withstand an attack is thereby reduced.[144] Types of geometric designs recommended by CISA include "chicanes and offset approaches" to a protected area, creating an indirect route to a protected area, and preventing vehicle access from the vicinity of the front of a protected area.[145]

[143] Institute of Transportation Engineers, "Geometric Design," Technical Resources, accessed July 20, 2022, https://www.ite.org/technical-resources/topics/geometric-design/.

[144] Cybersecurity and Infrastructure Security Agency, *Dams Sector*, 3.

[145] Cybersecurity and Infrastructure Security Agency, 2.

APPENDIX C. EXAMPLES OF PERMANENT, SEMI-PERMANENT, AND TEMPORARY INFRASTRUCTURE

A. PERMANENT

1. Example 1: EAG070-40 ST (C)-Bollard

Manufactured by Eagle Animation Ltd, this VSB is tested to the PAS 68 standard and has a performance rating of V/7500[N2]64/90:0/0.0. The manufacturer specifies that the foundation of this VSB is to be at a depth in excess of .5 meters below ground.[146] This VSB has a diameter, depending on the model, of either 219mm or 273mm and has been rated to withstand an impact from a vehicle up to 7.5 tons at a speed of 40 miles per hour.[147] The EAG070-40 ST (C)-Bollard is a standard bollard that is considered a passive and static piece of infrastructure. For the purposes of this thesis, it is considered permanent due to its foundation, performance rating, standard of testing, and overall capability.

[146] "EAG070-40ST (C) Bollard," Centre for the Protection of National Infrastructure, accessed June 24, 2022, https://www.cpni.gov.uk/hvm-impact-rated/eag070-40st-c-bollard.

[147] Eagle Automation Systems Ltd, "PAS68 Static Bollards EAG07000" (Essex, UK: Eagle Automation Systems Ltd, June 25, 2022), https://eagleautogate.co.uk/datasheets/pas68-iwa14-1/static-bollards/pas68-static-bollards-eag07000.

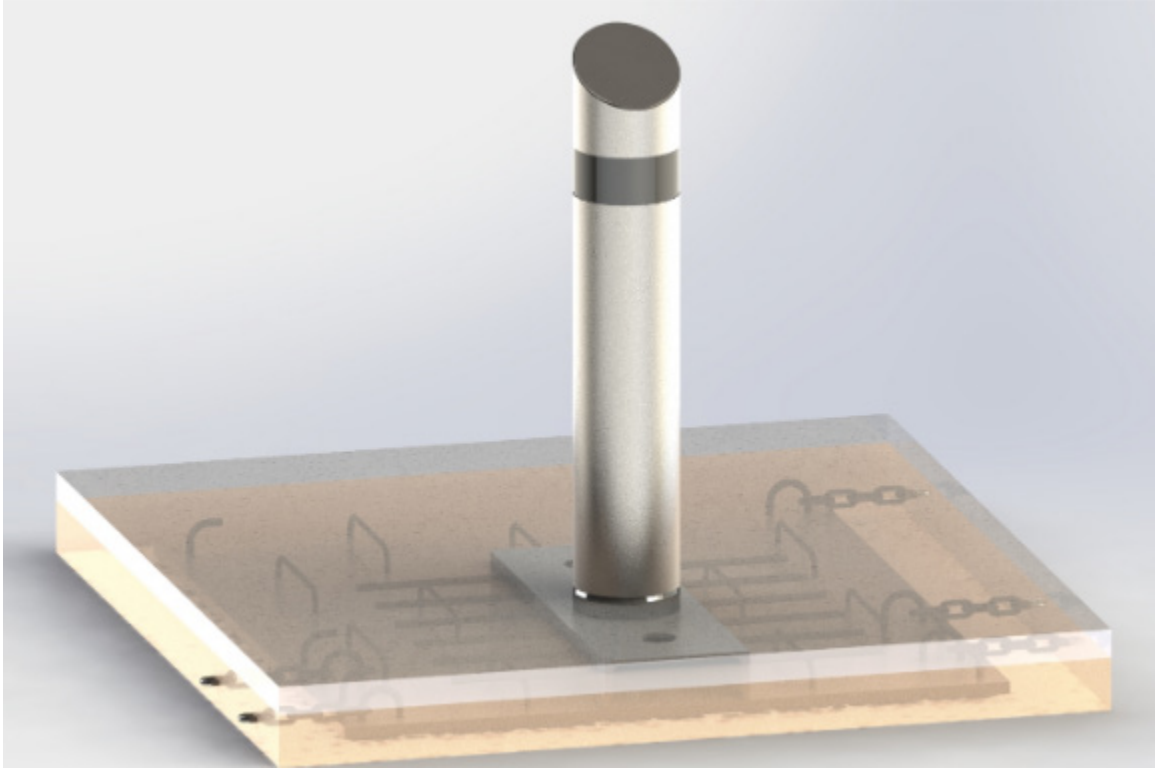

Figure 8. EAG070-40ST (C) Bollard[148]

2. Example 2: Wedge II

Manufactured by Perimeter Protection Germany GmbH, this VSB is tested to the PAS 68 standard as well as the ISO IWA 14-1:2013 standard and has a performance rating of V/7200[N3C]/80/90:0.0. The manufacturer specifies that the foundation of this VSB is to be at a depth of 300 millimeters below ground.[149] This VSB has a height of 1048 millimeters and a width of 3980 millimeters.[150] The Wedge II is a retractable blocker that is considered to be an active piece of infrastructure. For the purposes of this thesis, it is considered permanent due to its foundation, size, performance rating, standard of testing, and overall capability.

[148] Source: Eagle Automation Systems Ltd.

[149] Perimeter Protection Group, "Wedge II," Wedge Barriers – Security For Highly Sensitive Entry Points, accessed June 24, 2022, https://www.cpni.gov.uk/hvm-impact-rated/wedge-ii.

[150] Perimeter Protection Group.

Figure 9. Wedge II[151]

3. Example 3: RhinoGuard Verso 600 Block and 15–30 Ground Frame Assembly

Manufactured by Marshalls, this VSB is tested to the ISO IWA 14-1:2013 standard and has a performance rating of V/1500[M1]/48/90:5.4.[152] The manufacturer specified that the foundation of this VSB is to be at a depth of 250 millimeters using a foundation of C30 grade concrete.[153] It is 550 millimeters high and 600 millimeters wide.[154] The RhinoGuard Verso 600 Block is a large concrete block and is considered to be a passive piece of infrastructure. For the purposes of this thesis, it is considered

[151] Source: Perimeter Protection Group.

[152] "RhinoGuard Verso 600 Block and 15-30 Ground Frame Assembly," Centre for the Protection of National Infrastructure, accessed June 7, 2022, https://www.cpni.gov.uk/hvm-impact-rated/rhinoguard-verso-600-block-and-15-30-ground-frame-assembly.

[153] Marshalls, "RhinoGuard Verso 1200 Block 15-30 - Complete," Product Specification, April 29, 2021, https://media.marshalls.co.uk/image/upload/v1629188116/PS-VR-SE-00021-RhinoGuard-Verso-15-30-1200-Basic-Spec.pdf.

[154] Centre for the Protection of National Infrastructure, "RhinoGuard Verso 600 Block and 15-30 Ground Frame Assembly."

permanent due to its foundation, size, performance rating, standard of testing, and its overall capability.

Figure 10. RhinoGuard Verso 600 Block and 15–30 Ground Frame Assembly[155]

B. SEMI-PERMANENT

1. Example 1: Securipod Barrier MKII

Manufactured by Securiscape Ltd., this VSB is freestanding, is tested to the ISO IWA 14-1:2013 standard, and has a performance rating of V/7200[N3C]/32/90:8.5.[156] According to the manufacturer, the VSB's design combined with "the weight of the pod, plus its innovative Claw system, stops it from moving any further forward or backward,

[155] Source: Centre for the Protection of National Infrastructure.

[156] Centre for the Protection of National Infrastructure, "Securipod Barrier MKII," Centre for the Protection of National Infrastructure, accessed June 26, 2022, https://www.cpni.gov.uk/hvm-impact-rated/securipod-barrier-mkii.

preventing further damage and loss of life."[157] The Securipod Barrier MKII is a series of multiple interconnected pods that is able to disable a hostile vehicle, allow pedestrian access, and can be deployed in a small area or, if coupled with multiple units, can be deployed in a larger area. Each set of pods should be considered a unit and each unit is 785 millimeters high and 14060 millimeters wide.[158] It is considered to be a passive piece of infrastructure. For the purposes of this thesis, it is considered semi-permanent due to its lack of foundation, size, performance rating, the standard of testing, and overall capability.

Figure 11. Securipod Barrier MKII [159]

[157] "HVM Securipods," Securiscape, 2022, https://www.securiscape.co.uk/hvm-securipods/.

[158] Centre for the Protection of National Infrastructure, "Securipod Barrier."

[159] Source: Centre for the Protection of National Infrastructure.

2. Example 2: Vertical Opening Gate

Manufactured by Systra Ltd., this VSB is tested to the PAS 68 standard and has a performance rating of V/7500[N2]/48/90:4.7/0.[160] This VSB is a "hinge barrier" connected to a gate barrier via a gate boom.[161] The vertical opening gate is designed to be placed in an area that may be susceptible to a VRA but that authorized vehicles may also need to access. As such, the gate barrier is designed to open in a vertical fashion to allow access to those authorized vehicles. It is considered to be an active piece of infrastructure due to this operability. The vertical opening gate is 9422 millimeters wide, 2118 millimeters tall and the gap available in the infrastructure is available up to 6.5 meters.[162] For the purposes of this thesis, it is considered semi-permanent due to its lack of foundation, size, performance rating, the standard of testing, and overall capability.

[160] Systra, *Redeployable Hostile Vehicle Mitigation (HVM) Measures* (Wolvermampton, UK: Zaun, 2021), 10, https://www.zaun.co.uk/media/2021/04/SYSTRA-Redeplyable-HVM-Temporary-Component-Catalogue-JAN-2021.pdf.

[161] Systra, 10.

[162] Systra, Redeployable.

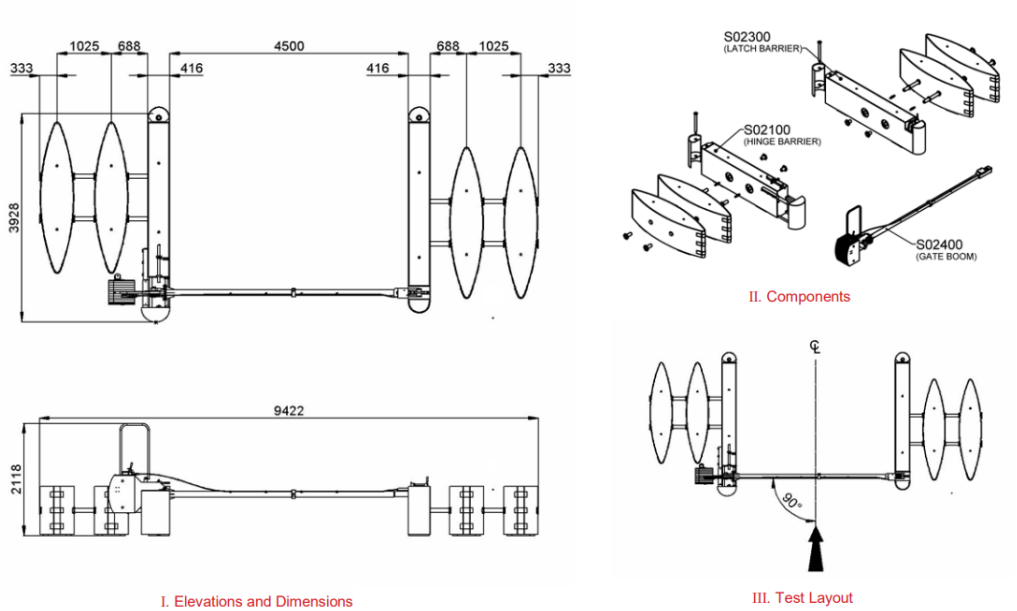

Figure 12. Vertical Opening Gate [163]

3. Example 3: Terra Ultimate 180° Swing Barrier

Manufactured by Frontier Pitts Ltd., this VSB is tested to the ISO IWA 14-1:2013 standard and has a performance rating of V/7200[N2A]/80/90:4.7/0.[164] This VSB is essentially two bollards embedded into the ground that are connected via a gate barrier. The Terra Ultimate 180° Swing Barrier is designed to be placed in an area that may be susceptible to a VRA but that authorized vehicles may also need to access. As such, the gate barrier is secured by a lock and key and designed to open in a horizontal fashion by the keyholder to allow access to those authorized vehicles. According to the manufacturer, this VSB has "an anti-tamper mechanism which encases the gates locking pin and is resistant from attack by a wide array of hand tools and battery powered tools."[165] It is considered to be an active piece of infrastructure due to this operability.

[163] Source: Systra.

[164] "Terra Ultimate 180 Swing Barrier," Centre for the Protection of National Infrastructure, 2022, https://www.cpni.gov.uk/hvm-impact-rated/terra-ultimate-180-swing-barrier.

[165] "IWA14 Terra 180° Swing Barrier," Frontier Pitts, 2022, https://www.frontierpitts.com/products/barriers/hvm-barriers/iwa-14-terra-180/.

The vertical opening gate is 7255 millimeters wide, 1100 millimeters tall, and has an aperture of 6000 millimeters.[166] The Terra Ultimate 180° Swing Barrier has the ability to successfully operate with a minimal foundation depth of 350 millimeters.[167] For the purposes of this thesis, it is considered semi-permanent due to its foundation, size, performance rating, the standard of testing, and overall capability.

Figure 13. Terra Ultimate 180° Swing Barrier [168]

C. TEMPORARY

1. Example 1: Crash Block 40

Manufactured by Safetyflex Barriers, this VSB is tested to the ISO IWA 14-1:2013 standard, has a performance rating of V/7200[N2A]/64/90:6.7, and is

[166] Centre for the Protection of National Infrastructure, "Terra Ultimate 180 Swing Barrier."

[167] Frontier Pitts, "IWA14 Terra 180° Swing Barrier."

[168] Source: Centre for the Protection of National Infrastructure, "Terra Ultimate 180 Swing Barrier."

freestanding.[169] This VSB has a height of 870 millimeters and a width of 2000 millimeters.[170] The Crash Block 40 can either be considered a blocker or a piece of street furniture as it "can be fitted with a Planter with seating benches."[171] It is considered to be a passive piece of infrastructure. For the purposes of this thesis, it is considered temporary due to its lack of foundation, size, and short installation process.[172]

Figure 14. Crash Block 40[173]

2. Example 2: F-18

Manufactured by Pitagone, this VSB is intended to operate as a fence. According to the Centre for the Protection of National Infrastructure, this VSB is delay rated.[174]

[169] "Crashblock 30/40," Centre for the Protection of National Infrastructure, 2022, https://www.cpni.gov.uk/hvm-impact-rated/crashblock-3040.

[170] Centre for the Protection of National Infrastructure.

[171] "Crash Block 40," IWA 14 Crash Block 40, safetyflex, accessed June 28, 2022, https://www.safetyflexbarriers.com/products/anti-terrorist-security/crash-block-40-surface-mount/.

[172] safetyflex.

[173] Source: Centre for the Protection of National Infrastructure, "Crashblock 30/40."

However, the manufacturer specifies that it has been tested to the ratings of both the ISO IWA 14-1:2013 and PAS 68.[175] Each unit is an "L" shaped frame that can be connected to any number of other units via an "X" shaped connectors. It is considered to be a passive piece of infrastructure. This VSB has a height of 100 centimeters and the distance between each module may vary, depending on the user's preference, between 43 and 68 centimeters.[176] For the purposes of this thesis, it is considered temporary due to its lack of foundation, size, movability, and rating.

Figure 15. F-18[177]

[174] "F18 (8 Units)," Centre for the Protection of National Infrastructure, 2022, https://www.cpni.gov.uk/cse/f18-8-units.

[175] "Pitagone Anti-Ram Vehicle Barriers," ARX Perimeters, 2022, https://arxperimeters.com/products/pitagone-anti-ram-vehicle-barriers/.

[176] "F-18: Certified Modular Mobile Barrier," Pitagone, 2022, https://www.pitagone.com/en/home/f18.

[177] Source: Centre for the Protection of National Infrastructure, "F18 (8 Units)."

3. Example 3: Surface Guard Barrier

Manufactured by ATG Access, this VSB is delay rated portal-styled type of infrastructure.[178] The manufacturer specifies that the infrastructure is 700 millimeters high and 1185 millimeters wide and possesses a rating of V/7,200(N3C)/32/90:4.8.[179] Furthermore, the manufacturer describes it as "robust and effortless to install, making it the ideal temporary event security solution."[180] The Surface Guard Barrier is a passive piece of infrastructure. For the purposes of this thesis, it is considered temporary due to its lack of foundation, size, and mobility.

Figure 16. Surface Guard Barrier [181]

[178] "Surface Guard," Centre for the Protection of National Infrastructure, 2022, https://www.cpni.gov.uk/cse/surface-guard.

[179] ATG Access, "The Surface Guard System," Product Overview, accessed June 28, 2022, https://www.atgaccess.com/files/downloads/56-surface-guard.pdf.

[180] "Surface Guard System," ATG Access, accessed June 28, 2022, https://www.atgaccess.com/temporary-security/surface-guard.

[181] Source: ATG Access.

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APPENDIX D. CASE STUDIES OF PROMINENT PEDESTRIAN FATALITIES INVOLVING VEHICLE RAMMING ATTACKS AND VEHICLE-CAUSED PEDESTRIAN FATALITIES

A. INTRODUCTION

This appendix focuses on five real-world events to analyze the various major degrees of the THPSS. All of the events analyzed garnered international media attention and included video, photos, and a synopsis of the circumstances that proved to be advantageous to analyze each event through the lens of the THPSS. In each of these events, at least one individual other than the perpetrator was killed. Also, in each of these events, at least one individual other than the perpetrator was injured. All of the cases discuss the infrastructure that was available and in place immediately prior to the incident to aid in a more comprehensive analysis. Additionally, the background of the operator of the hostile vehicle is provided to illustrate any overlying themes and context. Each case was chosen for its newsworthiness and its ability to highlight the major degrees of the THPSS.

B. VEHICLE RAMMING ATTACKS/VEHICLE-CAUSED PEDESTRIAN FATALITIES

1. Münster, Germany

This section deciphers the events of the VRA that took place around 3:30 pm on April 7, 2018, outside of a local bar, Kiepenkerl, in Münster, Germany.[182] During this attack, two civilians were killed and 20 others were injured.[183] One additional civilian

[182] Chas Danner, "3 Dead After Van Drives Into Crowd in Münster, Germany," Intelligencer, April 7, 2018, https://nymag.com/intelligencer/2018/04/3-killed-after-van-drives-into-crowd-in-munster-germany.html.

[183] Souad Mekhennet and Michael Birnbaum, "Van Plows into Crowd in Northern German City of Münster, Killing at Least 2," *Washington Post*, April 7, 2018, https://www.washingtonpost.com/world/europe/van-plows-into-crowd-in-northern-german-city-of-munster-killing-at-least-3/2018/04/07/007e428c-3a75-11e8-b57c-9445cc4dfa5e_story.html.

succumbed to his injuries and died several weeks later, bringing the total civilian death toll to three.[184]

a. Infrastructure In Place During the Attack

Judging by images of the outside of the establishment taken before the incident, it does not appear that there was any permanent, semi-permanent, or temporary infrastructure.[185] Furthermore, according to images taken immediately after the incident, no permanent, semi-permanent, or temporary infrastructure is visible.[186] The landscape of the roadway in Münster was designed prior to the invention of the motor vehicle and, as such, is not fashioned to convey a large amount of vehicle traffic in an expeditious manner. The streetscape varies depending on the location in the city. Though there are some areas of the city where a vehicle can attain a high rate of speed, there are others where vehicles must slow their speed in order to successfully negotiate the turns and curves in the street safely. The outdoor dining area outside of Kiepenkerl was simply a pedestrianized section of the neighborhood fitted with tables, chairs, and other aesthetically pleasing items that were easily accessible to passing vehicles and fostered an environment in which vehicles and pedestrians were in close proximity.

b. Background of the Attacker

Jens Rüther was a 48-year-old German interior designer.[187] He was described as having "psychological problems" and "mental health episodes" dating as far back as

[184] "Münster Attack Victim Dies Weeks After Rampage," DW, April 26, 2018, https://www.dw.com/en/m%C3%BCnster-attack-victim-dies-weeks-after-rampage/a-43554269.

[185] "Kleiner Kiepenkerl Gerda Deckenbrock," Tripadvisor, November 2015, http://www.tripadvisor.com/Restaurant_Review-g187382-d1340365-Reviews-Kleiner_Kiepenkerl_Gerda_Deckenbrock-Muenster_North_Rhine_Westphalia.html.

[186] @FlexSnack, "#Münster #Kiepenkerl #Anschlag Schreckliche Bilder aus der Innenstadt...," Tweet, *Twitter*, April 7, 2018, https://twitter.com/FlexSnack/status/982637494956109826.

[187] Sarah White, "How ISIS Bataclan Attack Influenced German Heavy Metal Fanatic Who Killed Two by Ramming His Van into a Cafe in Münster," Daily Mail, April 9, 2018, http://www.dailymail.co.uk/news/article-5593727/German-heavy-metal-fan-drove-van-cafe-M-nster-avoided-Paris-Bataclan-ISIS-attack.html.

2014.[188] He had no known links to any terror organizations.[189] Before the incident, Rüther sent a note to loved ones detailing how he "suffered regular angry outbursts, lifelong impotence, periods of alcoholism, panic attacks and weeping spells."[190] Rüther had a history of petty crime that included "making threats, damaging property, a hit-and-run traffic accident, and fraud."[191] German prosecutors described Rüther as someone who expressed suicidal intentions.[192]

c. Background and Timeline

In the mid-afternoon on April 7, 2018, several dozen people were patronizing an outdoor dining area of a local restaurant called Kiepenkerl.[193] Images taken immediately after the incident show various shadows from buildings and pedestrians wearing light to medium clothing such as tank tops and T-shirts.[194] These images suggest that there was comfortable weather at the time of the incident, which would encourage some restaurant patrons to dine outdoors. Rüther was operating a "Volkswagen 'California' model camping van" in an area of the city "designated mainly for pedestrians near the city's cathedral."[195] Judging by the images of the vehicle in the aftermath of the attack, Rüther was driving in a westerly direction on a street called Spiekerhof. At approximately 3:27 pm, Rüther accelerated to a speed of about 30 miles per hour and deliberately crashed his

[188] Erik Kirschbaum, "German Authorities Say Driver in Fatal van Attack Had Long Record of Crimes and Apparently Acted Alone," World & Nation, April 8, 2018, https://www.latimes.com/world/europe/la-fg-germany-van-driver-20180408-story.html.

[189] White, "How ISIS Bataclan Attack Influenced German Heavy Metal Fanatic Who Killed Two by Ramming His Van into a Cafe in Münster."

[190] Derek Scally, "Münster Attacker's Father Says Son Was 'Tormented in His Head,'" The Irish Times, April 9, 2018, https://www.irishtimes.com/news/world/europe/munster-attacker-s-father-says-son-was-tormented-in-his-head-1.3456118.

[191] Elke Ahlswede, "Muenster Attacker Was Lone German with Mental Health Problems: Minister," Reuters, April 7, 2018, https://www.reuters.com/article/us-germany-crash-idUSKBN1HE0IQ.

[192] Kirsten Grieshaber and Dorothee Thiesing, "German van Driver in Attack in Muenster Had Run-Ins with Police, Suicidal Thoughts," Chicago Tribune, April 8, 2018, https://www.chicagotribune.com/nation-world/ct-muenster-germany-van-attack-20180408-story.html.

[193] Danner, "3 Dead After Van Drives Into Crowd in Münster, Germany."

[194] Danner.

[195] Kirschbaum, "German Authorities Say Driver in Fatal van Attack Had Long Record of Crimes."

vehicle into the outdoor eating area of the establishment.[196] The collision was intense enough that the vehicle plowed through all of the dining equipment and did not come to a stop "until it hit the pub's stone wall."[197] Rüther did not exit his vehicle after the collision and committed suicide with a gun that was later found by authorities inside his vehicle.[198] Rüther's vehicle was initially thought to have an explosive device inside in that there were "protruding wires. Police later found only illegal firecrackers that were disguised as a fake bomb and a fake pistol in the van, along with the real gun" Rüther used to commit suicide.[199]

d. Analysis

The 2018 Münster, Germany, incident represents a "completely open" scenario on the THPSS. The location possessed no sort of infrastructure to mitigate the risk of a VRA or a vehicle-caused pedestrian fatality. Though the general streetscape possessed features that could ensure traffic calming in some areas, the route that Rüther took prior to the VRA/collision did not possess these features. In fact, the road that Rüther utilized to approach Kiepenkerl had a general straightaway of sufficient distance to attain a lethal rate of speed. Additionally, there was no pedestrian pathway protection despite the apparent heavy use of an area with stationary pedestrians. The area had a substantial risk of a serious or deadly incident from something as hapless as a distracted driver to as nefarious as terrorism.

2. Halloween NYC Truck Attack

This section deciphers the events of the VRA that took place on October 31, 2017, on a bicycle/pedestrian path in New York City's lower Manhattan. During this attack,

[196] Kirschbaum.

[197] Grieshaber and Thiesing, "German van Driver in Attack in Muenster Had Run-Ins with Police."

[198] Kirschbaum, "German Authorities Say Driver in Fatal van Attack Had Long Record of Crimes."

[199] Kirschbaum.

eight civilians were killed and 12 others were injured.[200] This incident was "the deadliest terrorist attack on New York City since September 11, 2001."[201]

a. Infrastructure In Place During Attack

There was a fair amount of permanent infrastructure in place before the attack in that there was a 20-inch-high concrete barrier separating the bicycle/pedestrian path from adjacent vehicular traffic. This barrier is designed to keep out-of-control vehicles from crossing onto the path and coming into contact with pedestrians. However, there was an extremely limited amount of infrastructure to mitigate the risk of a VRA on the bicycle/ pedestrian path itself. The bicycle/pedestrian path has various ingress/egress points large enough to accommodate pedestrians. This area of Manhattan includes various commercial and public facilities that allow access to vehicles such as parking garages, entertainment venues, etc. For vehicles to access these facilities, they must cross over the bicycle/pedestrian path in any number of locations. There was no infrastructure in place to prevent vehicles from traveling onto the bicycle/pedestrian path, whether unwittingly or nefariously, and continuing traveling for an extended distance on the path.

b. Background of the Attacker

Sayfullo Saipov was born on February 8, 1988, in Tashkent, Uzbekistan.[202] In March 2010, Saipov came to the United States under the "Diversity Visa Program, a state department program which offers a lottery for people from countries with few immigrants in America."[203] Saipov lived in Ohio and Florida before eventually settling in Patterson,

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[200] U.S. Department of Justice, "Sayfullo Saipov Indicted On Terrorism And Murder In Aid Of Racketeering Charges In Connection With Lower Manhattan Truck Attack," The United States Attorney's Office Southern District of New York, November 21, 2017, https://www.justice.gov/usao-sdny/pr/sayfullo-saipov-indicted-terrorism-and-murder-aid-racketeering-charges-connection-lower.

[201] Benjamin Mueller et al., "Prosecutors Describe Driver's Plan to Kill in Manhattan Terror Attack," *New York Times*, November 1, 2017, https://www.nytimes.com/2017/11/01/nyregion/driver-had-been-planning-attack-in-manhattan-for-weeks-police-say.html.

[202] Amir Zhanuzakov, "Biography of the New York Terrorist: Who Is Saifulla Saipov," November 2, 2017, 365 info, https://365info.kz/2017/11/biografiya-nyu-jorskogo-terrorista-kto-takoj-sajfulla-saipov.

[203] Kim Barker, Joseph Goldstein, and Michael Schwirtz, "Finding a Rootless Life in U.S., Sayfullo Saipov Turned to Radicalism," *New York Times,* November 1, 2017, https://www.nytimes.com/2017/11/01/nyregion/sayfullo-saipov-truck-attack-manhattan.html.

New Jersey.[204] After undergoing a basic background check, Saipov started working for the ride-sharing service Uber, where he logged over 1,400 trips.[205]

c. Background and Timeline

At approximately 2:06 pm, Saipov rented "a pickup truck from a Home Depot in Passaic, New Jersey."[206] This standard 2016 Ford F250 has a 385 horsepower V8 engine and a gross vehicle weight rating of 10,000 pounds.[207] As captured via license plate readers, Saipov used the vehicle to cross the Hudson River by way of the George Washington Bridge at 2:43 pm and began his descent into lower Manhattan via the Henry Hudson Parkway, commonly known as the West Side Highway.[208] At 3:04 pm, the vehicle was captured on surveillance camera footage entering the bike path at the intersection of West Street and West Houston Street and continuing to drive south "at a high rate of speed."[209] The vehicle traveled approximately eight-tenths of a mile on the bike path and struck at least 19 people.[210] The vehicle finally "veered left toward Chambers Street, where it collided with a small school bus."[211] Saipov exited the vehicle and brandished a "pellet gun and a paintball gun."[212] Witnesses at the scene of Chambers and West Streets describe Saipov as yelling "Allahu Akbar," translated to English

[204] Corey Kilgannon and Joseph Goldstein, "'He Did Not Seem Like a Terrorist,'" *New York Times*, November 1, 2017ProQuest.

[205] Marco della Cava, "NYC Terror Suspect Drove More than 1,400 Trips for Uber after Passing Background Check," Tech News, November 1, 2017, https://www.usatoday.com/story/tech/news/2017/11/01/nyc-terror-suspect-drove-more-than-1-400-trips-uber-after-passing-background-check/820856001/.

[206] Anthony M. DeStefano, "Sensors, Scanners Shed Light on Terror Attack Suspect's Movements: Police Say License Plate Readers and Other Technology Showed Suspect Sayfullo Saipov Scouted Locations for Manhattan Terror Attack," *Newsday*, November 2, 2017, ProQuest.

[207] New York State Department of Motor Vehicles (NYS DMV). "Police Accident Report # MV-2017-001-002786." Internal document, NYS DMV, October 31, 2017.

[208] DeStefano, "Sensors."

[209] DeStefano.

[210] New York State Department of Motor Vehicles, "Police Accident Report."

[211] Renae Merle, Devlin Barrett, and Wesley Lowery, "NYC Truck Attack Kills 8 Vehicle Hurtles down Bike Path in Possible Terror Act," *Washington Post*, November 1, 2017, ProQuest.

[212] Sarah Maslin Nir and William K. Rashbaum, "Police Officer Ryan Nash Ended New York Rampage With 9 Bullets," New York Times, ProQuest.

meaning "God is great."[213] An NYPD police officer, Ryan Nash, was answering an unrelated 911 call near the scene when he and his partner became aware of the commotion.[214] Saipov was still holding the two weapons and, as the officers approached him, he turned toward them, causing Officer Nash to fire his department-issued firearm, striking him in the abdomen and ending the VRA.[215]

d. Analysis

The Halloween NYC Truck Attack incident represents a hybrid model scenario on the THPSS. The location possessed a large amount of infrastructure to mitigate the risk of a vehicle-caused pedestrian fatality specifically in that there was substantial pedestrian pathway protection. However, there were critical gaps in the infrastructure that left the path at substantial risk to a hostile vehicle operated by a smart actor. It was one of these many gaps that Saipov exploited to gain access to the pedestrian-rich environment. In order to enter the bike path, Saipov had to significantly slow his vehicle down and negotiate a turn. This gives credit to the general streetscape in the pedestrian-rich environment. However, once he gained access, the bike path possessed no features that could ensure traffic calming. There was no infrastructure physically on the bike path to mitigate the threat of a hostile vehicle after it had accessed the pedestrian-rich environment.

3. Westminster Bridge Attack

This section deciphers the events of the Westminster Bridge Attack that took place on March 22, 2017, on the Westminster Bridge and continued outside the Palace of Westminster in London, England. During this attack, Khalid Masood killed four civilians in a VRA before stabbing to death a police constable (PC) of the Metropolitan Police

[213] Colleen Long and Jake Pearson, "'Cowardly Act of Terror': Truck Driver Kills 8 on Bike Path," November 1, 2017, https://apnews.com/article/terrorism-us-news-ap-top-news-uzbekistan-north-america-aa83dfe6157f4214a5e92efaba4142c9.

[214] Nir and Rashbaum, "Police Officer Ryan Nash Ended New York Rampage With 9 Bullets."

[215] Long and Pearson, "'Cowardly Act of Terror.'"

Service.[216] Soon after, Masood was shot and killed by responding law enforcement officers.[217] Masood's attack is believed to have been inspired by ISIS.[218]

a. Infrastructure In Place During Attack

Judging by the physical path of the hostile vehicle, there does not appear to have been any reliable infrastructure or pedestrian pathway protection on the Westminster Bridge itself. Pedestrians and vehicles were in very close proximity. The infrastructure that was ultimately responsible for stopping the vehicle outside of the New Palace Yard was a fence. Though this fence did stop the hostile vehicle, it was originally designed to exclude pedestrians from the area and was not meant to act as a crash-rated vehicle device.

b. Background of the Attacker

Khalid Masood, who was born Adrian Russell Elms, was a 52-year-old British-born criminal who spent time in and out of prison throughout his life.[219] Masood was a convert to Islam and, though there is little documentation as to when or where he converted, he was described as "fervently religious."[220] At the time of the attack, Masood was known to MI5 as a "peripheral figure" but was "not part of the current intelligence picture."[221] Authorities believe that Masood had no direct links to ISIS but that he "may have been inspired by calls to arms against the West."[222]

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[216] Alistair Smout, "'Lives Torn Apart in 82 Seconds', UK Westminster Attack Inquest Hears," Reuters, September 10, 2018, https://www.reuters.com/article/us-britain-security-inquests-idUSKCN1LQ214.

[217] Dominic Casciani, "London Attack: British-Born Attacker 'Known to MI5,'" BBC News, March 23, 2017, https://www.bbc.com/news/uk-39363297.

[218] Dominic Evans and Omar Fahmy, "London Attack Bears Islamic State 'Signature' but No Clear Link," Reuters, March 24, 2017, https://www.reuters.com/article/us-britain-security-islamicstate-idUSKBN16V25A.

[219] Counter Extremism Project, "Khalid Masood," Extremist Leaders, 2022, https://www.counterextremism.com/extremists/khalid-masood.

[220] Counter Extremism Project.

[221] Casciani, "London Attack."

[222] Evans and Fahmy, "London Attack Bears Islamic State 'signature' but No Clear Link."

c. Background and Timeline

On March 16, 2017, Masood rented a Hyundai Tuscan from a well-known rental car agency in Birmingham before traveling to London where he conducted surveillance and even drove across the Westminster Bridge.[223] He stayed at a hotel in Brighton the night before the attack and was seen on surveillance footage chatting and laughing with the staff.[224] Hotel staff even recalled Masood saying "I'm off to London today" and that "London isn't what it used to be" before he checked out the morning of the attack.[225]

On March 22, 2017, at 2:40 pm, Masood maneuvered his rented vehicle onto the pedestrian sidewalk of the Westminster Bridge and accelerated to at least 40 miles per hour.[226] Driving toward the Palace of Westminster, Masood struck and killed four people.[227] Additionally, 29 people suffered serious injuries after being struck by the vehicle.[228] Masood's vehicle struck one victim with such force that she was thrown over the bridge's parapet and into the water of the River Thames below.[229] Masood finally crashed "into the east perimeter gates of the Palace of Westminster," which rendered his vehicle inoperable.[230]

After crashing, Masood exited his vehicle and continued on foot, holding two knives, and running through the "Carriage Gates vehicle entrance to the Palace of

[223] Belfast Telegraph, "Khalid Masood's Final Movements Prior to Westminster Attack Revealed in Footage," September 19, 2018, https://www.belfasttelegraph.co.uk/news/uk/khalid-masoods-final-movements-prior-to-westminster-attack-revealed-in-footage-37334271.html.

[224] Patrick Grafton-Green, "London Terror Attack Killer Told Hotel Workers 'London Isn't What It Used to Be,'" Crime, March 24, 2017, https://www.standard.co.uk/news/crime/london-attack-khalid-masood-told-hotel-workers-london-isn-t-what-it-used-to-be-before-driving-to-the-capital-a3498021.html.

[225] Grafton-Green.

[226] Gordon Rayner, "How 82 Seconds of Hell Started with a WhatsApp Message," *Telegraph*, March 27, 2017, ProQuest.

[227] Smout, "'Lives Torn Apart in 82 Seconds.'"

[228] Mark Lucraft, "Inquests Arising From The Deaths In The Westminster Terror Attack of 22 March 2017," Judiciary, December 19, 2018, 2, https://www.judiciary.uk/wp-con tent/uploads/2018/12/ Westminster-Terror-Attack-2018-0304.pdf.

[229] Lucraft, 24.

[230] Max Hill, *The Westminster Bridge Terrorist Attack, 22nd March 2017: Operation Classific : A Report on the Use of Terrorism Legislation* (London, England, 2018), 2, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/697221/ The_WestBridge_Attack_report_Accessible.pdf.

Westminster."[231] It was here that Masood encountered PC Keith Palmer, an unarmed member of the Metropolitan Police Service, who was stationed at the Carriage Gates.[232] "PC Palmer stepped forward to challenge" Masood when Masood began to attack Palmer with the knives he was carrying.[233] Palmer suffered multiple stab wounds and succumbed to his injuries.[234] Masood then proceeded farther into the area surrounding the palace of Westminster where he encountered "plain-clothed armed police officers" who shot and killed him ending the attack.[235] Masood's entire attack lasted just 82 seconds.[236]

d. Analysis

The 2017 Westminster Bridge Attack represents a completely open scenario on the THPSS. The Westminster Bridge possessed no infrastructure to mitigate the risk of a VRA or a vehicle-caused pedestrian fatality at the time of the attack. There was no pedestrian pathway protection despite the apparent heavy use of the area by pedestrians and the reputation of the location for being a worldwide tourist destination. The area had a substantial risk of a serious or deadly incident from incidents ranging from distracted drivers to terrorism.

The streetscape in the area of the attack was lacking simply because it occurred on a bridge. Total traffic elimination, controlled traffic barring, and traffic calming would interfere with the purpose of a bridge overtly designed to accommodate vehicles. However, though the bridge included a sidewalk for pedestrians, there was no pedestrian pathway protection features on the bridge, and, as such, pedestrians and vehicles operated in extremely close proximity to each other.

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[231] Lucraft, "Inquests Arising From The Deaths In The Westminster Terror Attack of 22 March 2017," 3.

[232] Lucraft, 3.

[233] Lucraft, 25.

[234] Lucraft, 25.

[235] Lucraft, 3.

[236] Lucraft, 3.

4. U.S. Capitol Car Attack

This section deciphers the events of the U.S. Capitol Car Attack that took place around 1:00 pm on April 2, 2021, at a security checkpoint at the U.S. Capitol Building in Washington, DC.[237] During this attack, one police officer was killed and one other was injured.[238] Additionally, the perpetrator, Noah Green, was shot and killed by responding police.[239]

a. Infrastructure in Place During Attack

After the January 6, 2021, Capitol Riot a temporary perimeter fence was installed around the perimeter of the Capitol Building, however, the fence was taken down prior to the U.S. Capitol Car Attack.[240] The fence was installed primarily to keep protestors and pedestrians out of the area as officials feared another storming of the Capitol.

The Capitol has approximately 7,000 bollards surrounding the 5.5-mile perimeter that were installed shortly after 9/11.[241] The Capitol Building has various vehicle checkpoints in front of special parking areas designated for Congressional "members, staff, and authorized personnel in support of the House of Representatives." These checkpoints are manned by the U.S. Capitol Police and have infrastructure that allows access to authorized vehicles while simultaneously preventing unauthorized vehicles from gaining access. These checkpoints are located in various places around the Capitol and are positioned approximately "100 yards from the entrance of the building."[242]

[237] Melissa Macaya et al., "Officer Killed in Attack near US Capitol," CNN, April 2, 2021, https://www.cnn.com/politics/live-news/capitol-security-threat-04-02-21/index.html.

[238] Macaya et al.

[239] Michael Balsamo, Nomaan Merchant, and Colleen Long, "Man Rams Car into 2 Capitol Police; 1 Officer, Driver Killed," Associated Press, April 3, 2021, https://web.archive.org/web/20210404010724/https://apnews.com/article/car-rams-capitol-barricade-add0fea76244f1755344aa856ee64ecd.

[240] Luke Broadwater, Emily Cochrane, and Zolan Kanno-Youngs, "Bracing for Biden and Protests, Officials Fortify the Capitol," *New York Times*, February 28, 2022, ProQuest.

[241] "Capitol Bollards," Atlas Obscura, August 10, 2017, https://www.atlasobscura.com/places/capitol-bollards.

[242] Balsamo, Merchant, and Long, "Man Rams Car into 2 Capitol Police."

b. Background of the Attacker

Noah Green was a "model student-athlete who showed no signs of mental health struggles or other issues" during his time in high school.[243] After graduating, Green attended Christopher Newport University where he played football.[244] However, in 2019 he "blamed former teammates for drugging him with Xanax" resulting in, what Green described as, his addiction.[245] After graduating in 2019 with a major in business, family members describe that Green "appeared to have mentally unraveled in the last several years."[246] Prior to the attack, Green was not known to law enforcement and had no criminal history.[247] In the days before the attack, Green took to social media to rant about his unemployment and disseminated several rambling posts and videos about the Nation of Islam while signing the posts as "Brother Noah X."[248] Furthermore, one of Green's social media posts included references to the "end times," and another on March 17, warned about the "last days of our world as we know it."[249] None of Green's social media posts could shed light on the reason he targeted the Capitol Building.

c. Background and Timeline

The evening before the attack, Green's brother described him as becoming violently ill. Green also sent text messages to his brother saying, "I'm sorry but I'm just

[243] Emily Davies, Justin Jouvenal, and Michael E. Miller, "Suspect in Capitol Attack Was Already Unraveling, Family and Friends Say," *Washington Post*, April 4, 2021, ProQuest.

[244] Davies, Jouvenal, and Miller.

[245] Davies, Jouvenal, and Miller.

[246] Christal Hayes, "Suspect in Attack at U.S. Capitol Described as Average Jock Whose Mental Health Appeared to Quickly Unravel," USA Today, April 3, 2021, https://www.usatoday.com/story/news/politics/2021/04/02/noah-green-went-from-football-player-posting-extremist-groups/7068100002/.

[247] Dareh Gregorian, Leigh Ann Caldwell, and Jonathan Dienst, "U.S. Capitol Police Officer Dies after Attacker Rammed Car into Checkpoint; Suspect Also Dead," NBC News, April 2, 2021, https://www.nbcnews.com/politics/congress/suspect-custody-after-car-rams-two-officers-u-s-capitol-n1262917.

[248] Davies, Jouvenal, and Miller, "Suspect in Capitol Attack Was Already Unraveling."

[249] Gregorian, Caldwell, and Dienst, "U.S. Capitol Police Officer Dies after Attacker Rammed Car into Checkpoint."

going to go and live and be homeless" and "Thank you for everything you have done."[250]

On April 2, 2021, at approximately 1 pm, U.S. Capitol Police officers were on post at a security checkpoint at the "north vehicle access point along Constitution Avenue."[251] The security checkpoint that is "typically used by Senators and staff on weekdays."[252] It was at this time that Green drove a Nissan Altima at a high rate of speed toward the officers. After striking two officers, Green's vehicle collided with a "retractable barricade," a permanent piece of infrastructure. Green then exited his crashed vehicle "with a knife in his hand and started running" at officers.[253] Green was shot by officers and "died a short while later."[254]

One officer who was struck by Green's vehicle was removed to a local hospital in "stable and non-life threatening condition."[255] The other, Police Officer William Francis "Billy" Evans was transported via a "patrol car to a nearby hospital" but ultimately succumbed to his injuries.[256]

d. Analysis

The 2021 U.S. Capitol Car Attack represents a completely hardened scenario on the THPSS. The location possessed significant infrastructure to mitigate the risk of a VRA or a vehicle-caused pedestrian fatality on the grounds of the Capitol. Though the general streetscape possessed features that could ensure traffic calming in areas within the Capitol grounds, the streetscape within the grounds was trivial given the amount of

[250] Davies, Jouvenal, and Miller, "Suspect in Capitol Attack Was Already Unraveling."

[251] "Police Officer William Francis Evans," Officer Down Memorial Page, , accessed August 23, 2022, https://www.odmp.org/officer/25223-police-officer-william-francis-evans.

[252] Balsamo, Merchant, and Long, "Man Rams Car into 2 Capitol Police."

[253] Balsamo, Merchant, and Long.

[254] Josie Ensor, Jamie Johnson, and David Millward, "US Capitol Police Officer Killed and Another Injured in Car Ramming," *The Telegraph*, April 2, 2021, https://www.telegraph.co.uk/news/2021/04/02/us-capitol-building-locked-reports-gunshots/.

[255] The U.S. Capitol Police [@CapitolPolice], "UPDATE: The Other USCP Officer Who Was Struck by the Car Is in Stable and Non-Threatening Condition.," Tweet, *Twitter*, April 2, 2021, https://twitter.com/CapitolPolice/status/1378105541755539456.

[256] Officer Down Memorial Page, "Police Officer William Francis Evans."

permanent infrastructure in the area. The area had a limited risk of a serious or deadly incident within the grounds stemming from a VRA. Security checkpoints, like the one Police Officers Evans was posted at, served to be vital in limiting these sorts of attacks. The checkpoints, however, essentially served as chokepoints for a nefarious actor intent on utilizing a VRA as their means to conduct their ill-intended action. Stationing members of the U.S. Capitol Police at such a chokepoint simply placed them in the position of becoming victims instead of first responders.

5. Richard Rojas Times Square Incident

This section deciphers the events of the vehicle-caused pedestrian fatality that took place around 12:00 pm on May 18, 2017, on the sidewalk on New York City's Times Square.[257] During this attack, one civilian was killed and 22 others were injured.[258]

a. Infrastructure In Place During Attack

Based on this author's intimate knowledge Times Square, there was a moderate amount of semi-permanent and temporary infrastructure in place in the area in the form of bollards and street furniture.[259] These pieces of infrastructure were installed or placed sporadically on the sidewalk. The landscape of the streets in the Times Square area is generally flat and is fashioned to convey a large amount of vehicle traffic in a semi-expeditious manner. The streetscape is in a grid format with only one street in the area not adhering to the North/South/East/West grid. Generally, vehicles in the area must slow their speed due to the frequent traffic lights and the high quantity of other vehicles. However, a vehicle can physically attain a high rate of speed with light traffic conditions.

[257] Daniel Trotta and Jonathan Allen, "Motorist Crashes into Times Square Crowd, Killing One Person, Injuring 22," Reuters, May 18, 2017, https://www.reuters.com/article/us-new-york-crash-idUSKCN18E2D1.

[258] Ray Sanchez, "Car Barrels into Pedestrians in New York's Times Square," CNN, May 18, 2017, https://www.cnn.com/2017/05/18/us/new-york-times-square-car-pedestrians/index.html.

[259] Mark Lungariello and Steven Hirsch, "Richard Rojas Found Not Responsible by Reason of Insanity," *New York Post*, June 22, 2022, https://nypost.com/2022/06/22/richard-rojas-found-not-guilty-by-reason-of-insanity/.

b. Background of the Attacker

Rojas had no ties to any terrorist organizations. Growing up in the Bronx, Rojas "enlisted in the (U.S.) Navy in July 2011.[260] During his time in the Navy, he was arrested on a "DUI [driving under the influence] charge [that] led to a dishonorable discharge from the Navy in 2014."[261] He was also arrested twice for driving while intoxicated (DWI) in New York in 2008 and in 2015.[262] Other run-ins with the law included grabbing a notary by the neck, threatening to kill police officers, and "battery and resisting [a police] officer" stemming from an incident in which he assaulted a cab driver.[263] Rojas's friends described "mounting aggression and mental health issues that began in childhood" though "he never sought or received treatment."[264] Though there is no record of Rojas ever being in combat during his military service, "friend have said he was never the same after leaving the Navy. They say his paranoia took over as he started drinking heavily and smoking marijuana and that he often spoke about 'conspiracies, demons and devils.'"[265]

c. Background and Timeline

At 10:30 am on May 18, 2017, Rojas left his Bronx apartment and traveled south to Manhattan.[266] Driving a 2009 Honda Accord, Rojas arrived in Times Square shortly before noon.[267] At about 11:54 am, Rojas was at the corner of West 42nd Street and 7th

[260] Benjamin Mueller and William K. Rashbaum, "Before Times Sq. Crash, A String of Legal Issues And a Fall Into Paranoia," *New York Times*, May 20, 2017, ProQuest.

[261] Phil McCausland, "Driver Behind Times Square Mayhem: 'I Wanted to Kill Them,'" U.S. News, May 19, 2017, https://www.nbcnews.com/news/us-news/driver-behind-times-square-mayhem-i-wanted-kill-them-n762176.

[262] Mueller and Rashbaum, "Before Times Sq. Crash, A String of Legal Issues And a Fall Into Paranoia."

[263] Mueller and Rashbaum.

[264] Mueller and Rashbaum.

[265] Emily Crane, "Times Square Killer in Court: Driver Says He Laced His Marijuana with PCP, as It's Revealed He Spent Time in a Military Prison, Heard Voices and 'Wasn't the Same after Being Discharged from the Navy,'" Daily Mail, May 19, 2017, http://www.dailymail.co.uk/~/article-4522752/index.html.

[266] Mueller and Rashbaum, "Before Times Sq. Crash, A String of Legal Issues And a Fall Into Paranoia."

[267] Sanchez, "Car Barrels into Pedestrians in New York's Times Square."

Avenue facing south when he made a U-turn, "jumped the sidewalk," and started traveling north at a high rate of speed.[268] For three city blocks from West 42nd Street to West 45th Street, Rojas accelerated and struck pedestrians before his vehicle struck a bollard at the intersection of West 45th Street and Broadway.[269] One woman, 18-year-old tourist Alyssa Elsman, was killed after she was run over by Rojas's vehicle.[270] Twenty-two others were injured during the rampage.[271] Immediately after his vehicle collided with a bollard, Rojas exited the car and ran around the area in a deranged manner while screaming, "'What happened?' 'Oh my God, what happened?'" before being subdued by a group of good Samaritans and an NYPD Traffic Agent.[272] Rojas, who admitted to authorities that "he smoked PCP-laced marijuana" before the incident, was "charged with aggravated vehicular homicide, 20 counts of attempted murder and second-degree murder."[273]

d. Analysis

This incident represents a hybrid scenario on the THPSS. The location possessed a moderate amount of infrastructure to mitigate the risk of a vehicle-caused pedestrian fatality as evidenced by the bollard that Rojas's vehicle struck. According to its manufacturer, Calpipe Security Bollards, the bollard "performed as intended, and in doing so prevented any further damage or injuries from occurring."[274] As is shown in the various surveillance videos of the incident, there are bollards installed throughout the

[268] Sanchez.

[269] Trotta and Allen, "Motorist Crashes into Times Square Crowd."

[270] Ronny Reyes and Paul Farrell, "'I Hope Someone in Rikers Does the Right Thing': Father of Girl, 18, Killed by Bronx Man When He Plowed SUV into Times Square Crowd Slams 'Clown' Who 'Knew Exactly What He Was Doing,'" Daily Mail, June 24, 2022, https://www.dailymail.co.uk/news/article-10948673/Schizophrenic-Bronx-man-said-want-kill-plowed-SUV-into.html.

[271] Sanchez, "Car Barrels into Pedestrians in New York's Times Square."

[272] Lungariello and Hirsch, "Richard Rojas Found Not Responsible by Reason of Insanity."

[273] McCausland, "Driver Behind Times Square Mayhem."

[274] Calpipe Security Bollards, "Protecting Lives in Times Square, NYC" (Downey, CA: Calpipe Security Bollards), accessed December 13, 2021, http://www.calpipebollards.com/wp-content/uploads/2017/11/times-square-case-study.pdf.

area.[275] However, most of these bollards are positioned in a linear fashion that is parallel with 7th Avenue, a major arterial road. The bollards are seemingly installed this way to prevent out-of-control vehicles from careening onto the sidewalk. Surveillance video of the incident also shows bollards that are clearly from a different manufacturer and positioned away from the street in a manner to protect a single building. There were critical gaps in the infrastructure that left the pedestrian sidewalk at substantial risk to a hostile vehicle operated by a smart actor. It was one of these many gaps that Rojas exploited to not only gain access to the sidewalk but continue his rampage for three city blocks. In order to attain a deadly rate of speed, Rojas clearly had an unobstructed linear path to conduct his attack, which is a poor reflection of the streetscape in the area. Once Rojas committed to operating his vehicle on the sidewalk, the area possessed no features that could ensure traffic calming. Credit can be given to the infrastructure in the area for stopping the attack. However, the amount of infrastructure was severely lacking in that Rojas was able to mount the sidewalk and continue unobstructed for three city blocks.

C. CONCLUSION

Through the analysis of the five cases, several lessons can be learned regarding the THPSS. The Münster, Germany, and Westminster Bridge Attack represent the completely open model of the THPSS. The Halloween NYC Truck Attack and the Richard Rojas Times Square Incident represent the hybrid model, whereas the U.S. Capitol Car Attack represents the completely hardened model. Based on the infrastructure in place at the time during the Münster, Germany incident and Westminster Bridge Attack, the occurrences would have been near impossible to prevent at these specific locations. Furthermore, these two events would have been near impossible to stop once they began. The Halloween NYC Truck Attack and the Richard Rojas Times Square Incident had systems in place to prevent such incidents; however, the nature of the locations as a hybrid model made VRAs or a significant vehicle-caused pedestrian fatality less likely though not out of the realm of possibility. The U.S. Capitol Car Attack was a classic example of a security checkpoint simply being pushed a significant distance

[275] Lungariello and Hirsch, "Richard Rojas Found Not Responsible by Reason of Insanity."

away from a potential target. Though the incident was seemingly unpreventable, the completely hardened aspect of the location prevented the perpetrator from causing further damage to the overall location. All of the events included a perpetrator who could not have been arrested or otherwise detained prior to the respective incident. Each incident contained some combination of mental illness or terrorism, a considerable challenge to account for when stakeholders are considering which aspect of the THPSS to employ in a given area.

LIST OF REFERENCES

Ahlswede, Elke. "Muenster Attacker Was Lone German with Mental Health Problems: Minister." Reuters, April 7, 2018. https://www.reuters.com/article/us-germany-crash-idUSKBN1HE0IQ.

ARX Perimeters. "Pitagone Anti-Ram Vehicle Barriers." 2022. https://arxperimeters.com/products/pitagone-anti-ram-vehicle-barriers/.

ATG Access. "Surface Guard System." Accessed June 28, 2022. https://www.atgaccess.com/temporary-security/surface-guard.

———. "The Surface Guard System." Product Overview. Accessed June 28, 2022. https://www.atgaccess.com/files/downloads/56-surface-guard.pdf.

Atlas Obscura. "Capitol Bollards," August 10, 2017. https://www.atlasobscura.com/places/capitol-bollards.

Balsamo, Michael, Nomaan Merchant, and Colleen Long. "Man Rams Car into 2 Capitol Police; 1 Officer, Driver Killed." Associated Press, April 3, 2021. https://web.archive.org/web/20210404010724/https://apnews.com/article/car-rams-capitol-barricade-add0fea76244f1755344aa856ee64ecd.

Barker, Kim, Joseph Goldstein, and Michael Schwirtz. "Finding a Rootless Life in U.S., Sayfullo Saipov Turned to Radicalism." *New York Times.* November 1, 2017. https://www.nytimes.com/2017/11/01/nyregion/sayfullo-saipov-truck-attack-manhattan.html.

Belfast Telegraph. "Khalid Masood's Final Movements Prior to Westminster Attack Revealed in Footage." September 19, 2018. https://www.belfasttelegraph.co.uk/news/uk/khalid-masoods-final-movements-prior-to-westminster-attack-revealed-in-footage-37334271.html.

Boston Athletic Association. "126th Boston Marathon Post-Race Stats and Storylines," 2021. https://www.baa.org/126th-boston-marathon-post-race-stats-and-storylines.

———. "Marathon Dates." 2021. https://www.baa.org/races/boston-marathon/plan/marathon-dates.

Broadwater, Luke, Emily Cochrane, and Zolan Kanno-Youngs. "Bracing for Biden and Protests, Officials Fortify the Capitol." *New York Times*. February 28, 2022. ProQuest.

Calpipe Security Bollards. "Protecting Lives in Times Square, NYC." Downey, CA: Calpipe Security Bollards. Accessed December 13, 2021. http://www.calpipebollards.com/wp-content/uploads/2017/11/times-square-case-study.pdf.

Casciani, Dominic. "London Attack: British-Born Attacker 'Known to MI5.'" BBC News. March 23, 2017. https://www.bbc.com/news/uk-39363297.

Cava, Marco della. "NYC Terror Suspect Drove More than 1,400 Trips for Uber after Passing Background Check." Tech News, November 1, 2017. https://www.usatoday.com/story/tech/news/2017/11/01/nyc-terror-suspect-drove-more-than-1-400-trips-uber-after-passing-background-check/820856001/.

Centre for the Protection of National Infrastructure. "About CPNI." August 9, 2021. https://www.cpni.gov.uk/about-cpni.

———. "CPNI Advice Note: Due Diligence in the Selection and Procurement of Vehicle Security Barriers." London, England: Centre for the Protection of National Infrastructure, June 18, 2019. https://www.cpni.gov.uk/system/files/documents/40/81/Advice%20Note%20-%20Due%20Diligence%20in%20selecting%20barriers%20-%2003%20March%202020%20v3.pdf.

———. "Crashblock 30/40." 2022. https://www.cpni.gov.uk/hvm-impact-rated/crashblock-3040.

———. "CSE Chapter: HVM - Delay Rated." 2022. https://www.cpni.gov.uk/cse-chapter-hvm-delay-rated.

———. "EAG070-40ST (C) Bollard." Accessed June 24, 2022. https://www.cpni.gov.uk/hvm-impact-rated/eag070-40st-c-bollard.

———. "F18 (8 Units)." 2022. https://www.cpni.gov.uk/cse/f18-8-units.

———. "HVM - Impact Rated - Rating System Explained." London, England: Centre for the Protection of National Infrastructure, February 1, 2021. https://www.cpni.gov.uk/sites/default/files/citvsb_catalogue/CSE%20HVM%20-%20Impact%20Rated%20-%20Rating%20System%20Explained%20-%2020210201_0_0.pdf.

———. "HVM Schemes for the Streetscape." London, England: Centre for the Protection of National Infrastructure, March 2021. https://www.cpni.gov.uk/resources/cpni-hvm-schemes-high-street.

———. “Impact Testing of Vehicle Security Barriers.” London, England: Centre for the Protection of National Infrastructure, August 2020. https://www.cpni.gov.uk/system/files/documents/26/e5/CPNI%20-%20Impact%20Testing%20of%20Vehicle%20Security%20Barriers%20-%2018%20August%202020%5b2%5d.pdf.

———. “Protecting Your Assets.” March 30, 2021. https://www.cpni.gov.uk/protecting-your-assets.

———. “RhinoGuard Verso 600 Block and 15–30 Ground Frame Assembly.” Accessed June 7, 2022. https://www.cpni.gov.uk/hvm-impact-rated/rhinoguard-verso-600-block-and-15-30-ground-frame-assembly.

———. “Securipod Barrier MKII.” Accessed June 26, 2022. https://www.cpni.gov.uk/hvm-impact-rated/securipod-barrier-mkii.

———. “Surface Guard.” 2022. https://www.cpni.gov.uk/cse/surface-guard.

———. “Terra Ultimate 180 Swing Barrier.” 2022. https://www.cpni.gov.uk/hvm-impact-rated/terra-ultimate-180-swing-barrier.

CommercialCafe. “Office Building of The Week: One World Trade Center, NYC.” November 6, 2018. https://www.commercialcafe.com/blog/office-building-week-one-world-trade-center-nyc/.

Complete Communities Toolbox. “Streetscaping.” Accessed January 14, 2023. https://www.completecommunitiesde.org/planning/complete-streets/streetscaping/.

Counter Extremism Project. “Khalid Masood.” Extremist Leaders, 2022. https://www.counterextremism.com/extremists/khalid-masood.

Crane, Emily. “Times Square Killer in Court: Driver Says He Laced His Marijuana with PCP, as It’s Revealed He Spent Time in a Military Prison, Heard Voices and ‘Wasn’t the Same after Being Discharged from the Navy.’” Daily Mail, May 19, 2017. http://www.dailymail.co.uk/~/article-4522752/index.html.

Cybersecurity and Infrastructure Security Agency. “About CISA.” Accessed January 23, 2023. https://www.cisa.gov/about-cisa.

———. *Dams Sector: Active and Passive Vehicle Barriers Guide*. Washington, DC: Cybersecurity and Infrastructure Security Agency, 2020. https://www.cisa.gov/sites/default/files/publications/CISA_Dams_Sector_Active_and_Passive_Vehicle_Barriers_Guide_100220_508.pdf.

———. “Guide to Active Vehicle Barrier (AVB) Specification and Selection Resources.,” 2020. https://www.cisa.gov/sites/default/files/publications/Guide-to-Active-Vehicle-Barrier-2014-508.pdf.

———. “Protecting Patrons in Outdoor Eating Venues.” Washington, DC: Department of Homeland Security, 2021. https://www.cisa.gov/sites/default/files/publications/CISA_Protecting%20Patrons%20in%20Outdoor%20Eating%20Venues_Fact%20Sheet_508.pdf.

———. “Vehicle Ramming: Security Awareness for Soft Targets and Crowded Places.” Washington, DC: Department of Homeland Security. Accessed December 14, 2021. https://www.hsdl.org/?abstract&did=812645.

Danner, Chas. “3 Dead After Van Drives Into Crowd in Münster, Germany.” Intelligencer, April 7, 2018. https://nymag.com/intelligencer/2018/04/3-killed-after-van-drives-into-crowd-in-munster-germany.html.

Davies, Emily, Justin Jouvenal, and Michael E. Miller. “Suspect in Capitol Attack Was Already Unraveling, Family and Friends Say.” *Washington Post*. April 4, 2021ProQuest.

DeStefano, Anthony M. “Sensors, Scanners Shed Light on Terror Attack Suspect’s Movements: Police Say License Plate Readers and Other Technology Showed Suspect Sayfullo Saipov Scouted Locations for Manhattan Terror Attack.” *Newsday*. November 2, 2017. ProQuest.

DW. “Münster Attack Victim Dies Weeks After Rampage.” April 26, 2018. https://www.dw.com/en/m%C3%BCnster-attack-victim-dies-weeks-after-rampage/a-43554269.

Eagle Automation Systems Ltd. “PAS68 Static Bollards EAG07000.” Essex, UK: Eagle Automation Systems Ltd, June 25, 2022. https://eagleautogate.co.uk/datasheets/pas68-iwa14-1/static-bollards/pas68-static-bollards-eag07000.

Ensor, Josie, Jamie Johnson, and David Millward. “US Capitol Police Officer Killed and Another Injured in Car Ramming.” *Telegraph*. April 2, 2021. https://www.telegraph.co.uk/news/2021/04/02/us-capitol-building-locked-reports-gunshots/.

Evans, Dominic, and Omar Fahmy. “London Attack Bears Islamic State ‘signature’ but No Clear Link.” Reuters. March 24, 2017, https://www.reuters.com/article/us-britain-security-islamicstate-idUSKBN16V25A.

Fennelly, Lawrence J., and Marianna A. Perry. *CPTED and Traditional Security Countermeasures: 150 Things You Should Know*. Boca Raton, FL: CRC Press, 2018.

Frontier Pitts. "IWA14 Terra 180° Swing Barrier." 2022. https://www.frontierpitts.com/products/barriers/hvm-barriers/iwa-14-terra-180/.

Gauna, Danielle, Jack Brown, Kelsey Lu, Matthew Martinez, and Elizabeth Ablah. "An Evaluation of a Kansas Open Streets Event's Impact on Businesses." *Kansas Journal of Medicine* 14, no. 2 (2021): 187–91. https://doi.org/10.17161/kjm.vol1414662.

Grafton-Green, Patrick. "London Terror Attack Killer Told Hotel Workers 'London Isn't What It Used to Be.'" Crime, March 24, 2017. https://www.standard.co.uk/news/crime/london-attack-khalid-masood-told-hotel-workers-london-isn-t-what-it-used-to-be-before-driving-to-the-capital-a3498021.html.

Gregorian, Dareh, Leigh Ann Caldwell, and Jonathan Dienst. "U.S. Capitol Police Officer Dies after Attacker Rammed Car into Checkpoint; Suspect Also Dead." NBC News, April 2, 2021. https://www.nbcnews.com/politics/congress/suspect-custody-after-car-rams-two-officers-u-s-capitol-n1262917.

Grieshaber, Kirsten, and Dorothee Thiesing. "German van Driver in Attack in Muenster Had Run-Ins with Police, Suicidal Thoughts." *Chicago Tribune*, April 8, 2018. https://www.chicagotribune.com/nation-world/ct-muenster-germany-van-attack-20180408-story.html.

Hayes, Christal. "Suspect in Attack at U.S. Capitol Described as Average Jock Whose Mental Health Appeared to Quickly Unravel." USA Today, April 3, 2021. https://www.usatoday.com/story/news/politics/2021/04/02/noah-green-went-from-football-player-posting-extremist-groups/7068100002/.

Hazarika, Sanjukta. "'On Reclaiming the Streets for the People': Understanding Equity in Public Space Planning Strategies Through an Analysis of the Open Streets Program in New York City." Master's thesis, Columbia University, 2021. https://doi.org/10.7916/d8-ad9g-0g98.

Hess, Paul, and Sneha Mandhan. "Ramming Attacks, Pedestrians, and the Securitization of Streets and Urban Public Space: A Case Study of New York City." *URBAN DESIGN International* (2022): 1–16. https://doi.org/10.1057/s41289-022-00180-2.

Hesterman, Jennifer. *Soft Target Hardening: Protecting People from Attack*. Boca Raton, FL: CRC Press, 2015.

Hill, Max. *The Westminster Bridge Terrorist Attack, 22nd March 2017: Operation Classific : A Report on the Use of Terrorism Legislation*. London, England, 2018. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/697221/The_WestBridge_Attack_report_Accessible.pdf.

Institute of Transportation Engineers. "Geometric Design." Technical Resources. Accessed July 20, 2022. https://www.ite.org/technical-resources/topics/geometric-design/.

iTeh Standards. "IWA 14-1:2013 - Vehicle Security Barriers — Part 1: Performance Requirement, Vehicle Impact Test Method and Performance Rating." iTeh Standards Store, November 14, 2013. https://standards.iteh.ai/catalog/standards/iso/354777ba-e2c9-44d0-ac10-d5a345361763/iwa-14-1-2013.

Jenkins, Brian Michael, and Bruce R. Butterworth. *An Analysis of Vehicle Ramming as a Terrorist Tactic*. San Jose, CA: Mineta Transportation Institute, 2018. https://transweb.sjsu.edu/sites/default/files/SP0518%20Vehicle%20Ramming%20Terrorism.pdf.

Johnson, Chalmers. Blowback: The Costs and Consequences of American Empire. New York: Macmillan, 2000.

Kilgannon, Corey, and Joseph Goldstein. "'He Did Not Seem Like a Terrorist.'" *New York Times*. November 1, 2017. ProQuest.

Kirschbaum, Erik. "German Authorities Say Driver in Fatal van Attack Had Long Record of Crimes and Apparently Acted Alone." World & Nation, April 8, 2018. https://www.latimes.com/world/europe/la-fg-germany-van-driver-20180408-story.html.

Kotkova, Dora, Lukas Kralik, and Lukas Kotek. "Multiple Criteria Decision-Making: Risk Analyses for Cultural Events as One of the Soft Target Categories." In *2021 International Carnahan Conference on Security Technology (ICCST)*, 1–6, 2021. https://doi.org/10.1109/ICCST49569.2021.9717382.

Lee, Andrew Chee Keng, Hannah C. Jordan, and Jason Horsley. "Value of Urban Green Spaces in Promoting Healthy Living and Wellbeing: Prospects for Planning." *Risk Management and Healthcare Policy* 8 (2015): 131–37. https://doi.org/10.2147/RMHP.S61654.

Long, Colleen, and Jake Pearson. "'Cowardly Act of Terror': Truck Driver Kills 8 on Bike Path." Associated Press. November 1, 2017. https://apnews.com/article/terrorism-us-news-ap-top-news-uzbekistan-north-america-aa83dfe6157f4214a5e92efaba4142c9.

Lucraft, Mark. "Inquests Arising From The Deaths In The Westminster Terror Attack of 22 March 2017," Judiciary. December 19, 2018. https://www.judiciary.uk/wp-content/uploads/2018/12/Westminster-Terror-Attack-2018-0304.pdf.

Lungariello, Mark, and Steven Hirsch. "Richard Rojas Found Not Responsible by Reason of Insanity." *New York Post*, June 22, 2022. https://nypost.com/2022/06/22/richard-rojas-found-not-guilty-by-reason-of-insanity/.

Macaya, Melissa, Meg Wagner, Veronica Rocha, Melissa Klein, and Fernando Alfonso III. "Officer Killed in Attack near U.S. Capitol." CNN, April 2, 2021. https://www.cnn.com/politics/live-news/capitol-security-threat-04-02-21/index.html.

Marshalls. "RhinoGuard Verso 1200 Block 15–30 - Complete." Product Specification, April 29, 2021. https://media.marshalls.co.uk/image/upload/v1629188116/PS-VR-SE-00021-RhinoGuard-Verso-15-30-1200-Basic-Spec.pdf.

McCausland, Phil. "Driver Behind Times Square Mayhem: 'I Wanted to Kill Them.'" NBC News, May 19, 2017. https://www.nbcnews.com/news/us-news/driver-behind-times-square-mayhem-i-wanted-kill-them-n762176.

Mekhennet, Souad, and Michael Birnbaum. "Van Plows into Crowd in Northern German City of Münster, Killing at Least 2." *Washington Post*. April 7, 2018. https://www.washingtonpost.com/world/europe/van-plows-into-crowd-in-northern-german-city-of-munster-killing-at-least-3/2018/04/07/007e428c-3a75-11e8-b57c-9445cc4dfa5e_story.html.

Merle, Renae, Devlin Barrett, and Wesley Lowery. "NYC Truck Attack Kills 8 Vehicle Hurtles down Bike Path in Possible Terror Act." *Washington Post*. November 1, 2017. ProQuest.

Mueller, Benjamin, and William K. Rashbaum. "Before Times Sq. Crash, A String of Legal Issues And a Fall Into Paranoia." *New York Times*. May 20, 2017. ProQuest.

Mueller, Benjamin, William K. Rashbaum, Al Baker, and Adam Goldman. "Prosecutors Describe Driver's Plan to Kill in Manhattan Terror Attack." *New York Times*. November 1, 2017, https://www.nytimes.com/2017/11/01/nyregion/driver-had-been-planning-attack-in-manhattan-for-weeks-police-say.html.

Mullane, Patrick E. "Political Demonstrations: A Terrorist's Dream Opportunity." Master's thesis, Naval Postgraduate School, 2020. https://www.hsdl.org/?abstract&did=839418.

New York City Department of Transportation. "NYC Open Streets." Accessed October 24, 2022. https://www1.nyc.gov/html/dot/downloads/pdf/open-streets-overview.pdf.

———. "Open Restaurants." Pedestrians. Accessed October 20, 2022. https://www1.nyc.gov/html/dot/html/pedestrians/openrestaurants.shtml.

———. "Open Streets." Pedestrians, 2022. https://www1.nyc.gov/html/dot/html/pedestrians/openstreets.shtml.

———. “Open Streets Program 2022 Application.” Accessed October 25, 2022. https://www1.nyc.gov/html/dot/images/pedestrians/os-temp-limited-local-access-barrier-diagram.jpg.

———. “Summer Streets.” Summer Streets in NYC, 2022. https://www1.nyc.gov/html/dot/summerstreets/html/home/home.shtml.

———. “Summer Streets.” 2022. https://www1.nyc.gov/html/dot/summerstreets/html/route/event-map.shtml.

———. “Traffic Calming.” Traffic Calming. Accessed July 19, 2022. https://www.nycstreetdesign.info/geometry/traffic-calming.

New York City Office of the Mayor. “Mayor Adams Unveils Sweeping Plan for Holiday Season Car-Free Open Streets in Midtown Manhattan.” November 22, 2022. http://www1.nyc.gov/office-of-the-mayor/news/859-22/mayor-adams-sweeping-plan-holiday-season-car-free-open-streets-midtown-manhattan-.

New York State Department of Motor Vehicles. “Police Accident Report # MV-2017-001-002786.” Internal document, October 31, 2017.

Nir, Sarah Maslin, and William K. Rashbaum. “Police Officer Ryan Nash Ended New York Rampage With 9 Bullets.” *New York Times.* November 1, 2017. ProQuest.

Officer Down Memorial Page. “Police Officer William Francis Evans.” Accessed August 23, 2022. https://www.odmp.org/officer/25223-police-officer-william-francis-evans.

Pascus, Brian. “National 9/11 Memorial and Museum Sees Visitor Rebound.” Crain’s New York Business, September 9, 2002. https://www.crainsnewyork.com/hospitality-tourism/national-911-memorial-and-museum-sees-tourists-returning-new-york-city.

Perimeter Protection Group. “Wedge II.” Wedge Barriers – Security gor Highly Sensitive Entry Points. Accessed June 24, 2022. https://www.cpni.gov.uk/hvm-impact-rated/wedge-ii.

Pitagone. “F-18: Certified Modular Mobile Barrier.” 2022. https://www.pitagone.com/en/home/f18.

Rayner, Gordon. “How 82 Seconds of Hell Started with a WhatsApp Message.” *Telegraph*. March 27, 2017. ProQuest.

Reyes, Ronny, and Paul Farrell. "'I Hope Someone in Rikers Does the Right Thing': Father of Girl, 18, Killed by Bronx Man When He Plowed SUV into Times Square Crowd Slams 'Clown' Who 'Knew Exactly What He Was Doing.'" Daily Mail, June 24, 2022. https://www.dailymail.co.uk/news/article-10948673/Schizophrenic-Bronx-man-said-want-kill-plowed-SUV-into.html.

Roberts, Edward. "What Is IWA 14? The Definitive Guide to IWA 14-1." ATG Access, January 28, 2021. https://www.atgaccess.com/news/guides/what-is-iwa-14.

———. "What Is PAS 68? The Definitive Guide To BSI PAS 68." ATG Access, December 14, 2020. https://www.atgaccess.com/news/guides/what-is-pas-68.

———. "What Is PAS 170? The Definitive Guide." ATG Access, January 28, 2021. https://www.atgaccess.com/news/guides/what-is-pas-170.

safetyflex. "Crash Block 40." IWA 14 Crash Block 40 (Surface mount). Accessed June 28, 2022. https://www.safetyflexbarriers.com/products/anti-terrorist-security/crash-block-40-surface-mount/.

Sanchez, Ray. "Car Barrels into Pedestrians in New York's Times Square." CNN. May 18, 2017. https://www.cnn.com/2017/05/18/us/new-york-times-square-car-pedestrians/index.html.

Scally, Derek. "Münster Attacker's Father Says Son Was 'Tormented in His Head.'" The Irish Times, April 9, 2018. https://www.irishtimes.com/news/world/europe/munster-attacker-s-father-says-son-was-tormented-in-his-head-1.3456118.

Securiscape. "HVM Securipods." 2022. https://www.securiscape.co.uk/hvm-securipods/.

Sheppard, Ben. "Mitigating Terror and Avoidance Behavior through the Risk Perception Matrix to Augment Resilience." *Journal of Homeland Security and Emergency Management* 8, no. 1 (2011): 131–37. https://doi.org/10.2202/1547-7355.1840.

Smout, Alistair. "'Lives Torn Apart in 82 Seconds', UK Westminster Attack Inquest Hears." Reuters, September 10, 2018. https://www.reuters.com/article/us-britain-security-inquests-idUSKCN1LQ214.

Sunday Streets SF. "About." 2022. https://www.sundaystreetssf.com/about/.

———. "Sunday Streets Is Back, San Francisco!" 2022. https://www.sundaystreetssf.com/.

———. "Sunday Streets SF," 2022. https://www.sundaystreetssf.com/wp-content/uploads/2022/05/2022_PRINT8.5x11_SundayStreets.pdf.

Systra. *Redeployable Hostile Vehicle Mitigation (HVM) Measures*. Wolvermampton, UK: Zaun, 2021. https://www.zaun.co.uk/media/2021/04/SYSTRA-Redeplyable-HVM-Temporary-Component-Catalogue-JAN-2021.pdf.

TISO. "Guide to PAS 68:2013 Standard." Accessed July 18, 2022. https://tiso-blockers.com/news/472-guide-to-pas-68-2013-standard.

Tripadvisor. "Kleiner Kiepenkerl Gerda Deckenbrock." November 2015. http://www.tripadvisor.com/Restaurant_Review-g187382-d1340365-Reviews-Kleiner_Kiepenkerl_Gerda_Deckenbrock-Muenster_North_Rhine_Westphalia.html.

Trotta, Daniel, and Jonathan Allen. "Motorist Crashes into Times Square Crowd, Killing One Person, Injuring 22." Reuters. May 18, 2017. https://www.reuters.com/article/us-new-york-crash-idUSKCN18E2D1.

Unafor. "Certificates." 2021. https://unafor.com/certificates/.

U.S. Department of Justice. "Sayfullo Saipov Indicted On Terrorism And Murder In Aid Of Racketeering Charges In Connection With Lower Manhattan Truck Attack." The United States Attorney's Office Southern District of New York, November 21, 2017. https://www.justice.gov/usao-sdny/pr/sayfullo-saipov-indicted-terrorism-and-murder-aid-racketeering-charges-connection-lower.

U.S. Department of Transportation Federal Highway Administration. "Traffic Calming EPrimer - Module 2." Safety, February 14, 2017. https://safety.fhwa.dot.gov/speedmgt/ePrimer_modules/module2.cfm#mod21.

White, Sarah. "How ISIS Bataclan Attack Influenced German Heavy Metal Fanatic Who Killed Two by Ramming His Van into a Cafe in Münster." Daily Mail, April 9, 2018. http://www.dailymail.co.uk/news/article-5593727/German-heavy-metal-fan-drove-van-cafe-M-nster-avoided-Paris-Bataclan-ISIS-attack.html.

Young, Michelle. *Broadway*. Images of America. Charleston, SC: Arcadia Publishing, 2015.

Zhanuzakov, Amir. "Biography of the New York Terrorist: Who Is Saifulla Saipov?" 365info. November 2, 2017. https://365info.kz/2017/11/biografiya-nyu-jorskogo-terrorista-kto-takoj-sajfulla-saipov.

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